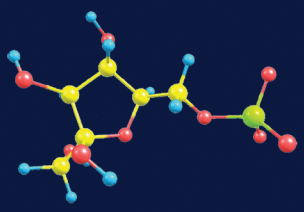
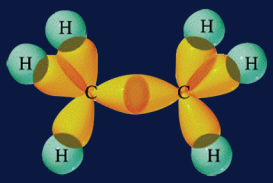
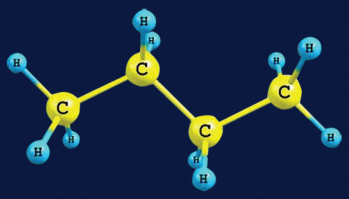
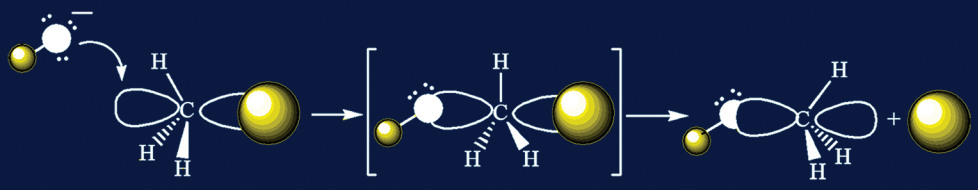
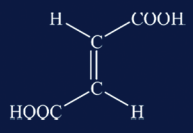
PharmaMed PRESS
An Imprint of Pharma Book Syndicate

Pharmaceutical Organic Chemistry

For B.Pharm. 2nd, 3rd and 4th Semesters as per PCI Revised Syllabus





CH_4

CH_3CH_3

$CH_3CH_2CH_3$

$CH_3CH_2CH_2CH_3$

$CH_3CH_2CH_2CH_2CH_3$

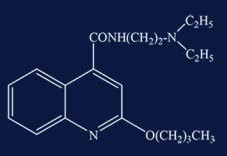
$CH_3CH_2CH_2CH_2CH_2CH_3$

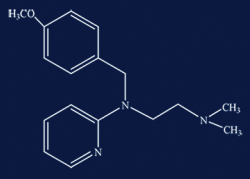
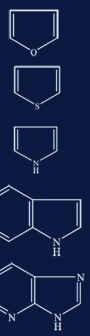
$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$

$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$




V. Alagarsamy

Pharmaceutical Organic Chemistry

Pharmaceutical Organic Chemistry

Dr. V. Alagarsamy

M. Pharm, PhD, FIC, DOMH.

Professor and Principal,
MNR College of Pharmacy,
Sangareddy - 502 294,
Gr. Hyderabad, TS, India.

PharmaMed Press

An imprint of Pharma Book Syndicate

A Unit of BSP Books Pvt. Ltd.
4-4-309/316, Giriraj Lane,
Sultan Bazar, Hyderabad - 500 095.

Pharmaceutical Organic Chemistry by *Dr. V. Alagarsamy*

Published by:

PharmaMed Press

An imprint of Pharma Book Syndicate

A Unit of BSP Books Pvt. Ltd.
4-4-309/316, Giriraj Lane, Sultan Bazar, Hyderabad - 500 095.
Phone: 040-23445600, 23445688; Fax: 91+40-23445611
E-mail: info@pharmamedpress.com
www.pharmamedpress.com/pharmamedpress.net

Printed at

Aditya Offset Process (I) Pvt. Ltd.
Hyderabad.

ISBN: 978-93-89354-77-5

Dedication

My First & Best Teacher - Beloved Mother

Gave me not only Respiration but also Inspiration

Shrimathi. V. KAMUTHAI

The inspirational words of my mother ringing in my ears are.....

"The two most important days in your life are the day you are born and the day you find out why you are born. In your life either write something worth reading or do something worth writing. You should dedicate yourself to your profession and do your best that should answer why you are born."

Whatever the mind of man can conceive and believe, it can achieve. Challenges are what makes life interesting and overcoming them is what makes life meaningful. In order to succeed in your life, your desire for success should be greater than your fear of failure. It does not matter how slowly you go as long as you do not stop.

We become what we think about; hence your thoughts should always be of high-quality. Definiteness of purpose is the starting point of all achievement. If you believe you can do it you are halfway there. Whatever you can do, or dream you can, begin it. Boldness has genius, power and magic in it. It will give you the required strength. "Nothing is Impossible in the world, because the word impossible itself says, I'm possible!"

When everything seems to be going against you, remember that the aircraft takes off against the wind, not with it. That is why it is reaching the desired destination. If you compromise for others, you cannot reach your destination, instead you will reach others destination.

Life shrinks or expands in proportion to one's courage. Limitations live only in our minds. But if we use our imaginations, our possibilities become limitless. Hence you have enough opportunities in the world if you have courage. Do what you can, where you are, with what you have. You should have a dream in your life and to achieve it if you have good idea and clear plan with full devotion, it will fetch you sure success even if the God says impossible. Because the hard work has its own power, it will never fail. You should not be a product of your circumstances. You should be a product of your decisions.

Preface

Pharmaceutical organic chemistry is the main branch of organic chemistry deals with the study of preparation, structure and reactions of organic compounds. As it deals with all the chemical reactions related to life, study of Pharmaceutical organic chemistry is important. Application of Organic chemistry in the development of pharmaceuticals, resulted in evolving Pharmaceutical organic chemistry. Hence studying Organic chemistry and applying this knowledge in Pharmaceutical substances is called as Pharmaceutical organic chemistry. Organic chemistry forms the basis of biochemistry, in which various aspects of health and diseases are studied. The biochemical knowledge is very important for the practice of nutritional, medical and related life sciences. In addition Organic chemistry paved way for the development of medicinal chemistry, Pharmaceutical organic chemistry, bioinformatics, biotechnology, gene therapy, Pharmacology, pathology, chemical engineering, dental science and so on. Organic substances play such a vital role in our daily life that all of us should know about organic chemistry in order to understand the manner how it influence our life process.

In the given conditions, a specific compound is inert or reactive, and if it is reactive, how will it react? Such knowledge will be used to design the structure of a substance that will have a specifically desired property. We will then know what substance to be used for making the parts for various instruments? Which drug to be used for a specific disease? Many of careers such as Doctors, Engineers, Pharmacists, Veterinarians, Dentists, Pharmacologists and Chemists make use of the knowledge of this fundamental subject. Hence the study of this basic Organic chemistry subject will make you to become successful professionals.

The field of organic chemistry is incredibly vast subject. Why is organic chemistry considered to be so difficult? in which "How to start" ? "What to study" ? and "How to study and remember the chemical reactions"? Is this either an antiquated misconception, or is absolutely true ? ? ?

The book has been designed to meet the needs of the intended readers with reference to the above questions.

Students should start learning organic chemistry by understanding only, not through mechanical memorization like "a poem learnt by rote in childhood". Organic chemistry is not a difficult subject, and once you understand, it will become an enjoyable subject and you blast your way by proposing your own way of reaction one after another.

This book is a product of my vision to design the best book on Pharmaceutical organic chemistry, which deals with the origin of organic chemistry, the concise description of structure of atom & organic molecules and their related properties, the nature of organic reactions & their mechanisms, nomenclature of organic compounds, clear classification of various organic compounds, preparation of each class of organic compounds by various routes, its chemical structure, physical properties and chemical reactions with the mechanism in a simplified manner and drugs derived from each class along with their applications in medicine. Swathing the entire features of Pharmaceutical organic chemistry, first of its kind, is the unique feature of this book. It facilitates the students to understand the subject more easily and make the subject interest.

As the students entering graduate course, understanding of Pharmaceutical organic chemistry is always been a difficult task especially the various chemical reactions with their mechanisms of different kind of organic compounds. Hence my efforts have been devoted to authoring a book by equipping with the challenging requirements of the subject for the new generations of the teachers all over India and is easy to read for students who are not necessarily of Pharmacy program, but mainly for the students of first time reading organic reactions, their mechanisms and their applications in science, Pharmacy and medicine.

Methodical description of each chapter, enriching chemical and pharmaceutical background of the medicinally important organic compounds, proceeding each group of organic compounds in a systematic way in easy-to-understand style in the larger interest of the students without any difficulty and making the reader acquainted thoroughly with chemistry of organic compounds is the unique feature of this book.

In preparing this text book, I have tried to enrich the importance of organic compounds in medicine and pharmacy, so that the anticipated audience of this book will feel the importance of organic compounds and made the book a comprehensive. The students of Pharmacy graduates of our country faced with the scarcity of books to serve their needs. Few of the authors dealt well about the basics of organic chemistry, but the reactions of organic compounds are not presented in a easy to understand manner which students felt difficult to learn. Some of the books of organic chemistry fail to give the chemical structures for all reactions, hence the students are unable to understand the reactions clearly. Hence the content of this book is made as a humble attempt to cater the needs of academicians belonging to all Indian Universities by incorporating the chemical structure of all reactions and enriching basic principles of each organic class of compounds.

The book has covered the entire Pharmaceutical organic chemistry, starting from origin of organic chemistry to advanced topics like stereochemistry and heterocyclic compounds and it is divided into 31 chapters. **Chapter 1 to 7** deals with the basics of the organic chemistry, wherein the fundamentals like origin and development of organic chemistry, structure of organic molecules and their related properties are described. Classification and nomenclature of organic compounds and general terms used are also presented in a systematic way, which is easy to understood and able to reproduce well in examinations.

Chapter 8 to 25 deals with Aliphatic and Aromatic compounds which are further divided into different chapters and each chapter is dealt with Introduction, Importance of each class of compounds, Nomenclature, General methods of preparation, General physical and chemical properties and Pharmaceutically important organic compounds of each chapter are described in a easy to understand manner. Summary of methods of preparation and chemical reactions in a flow chart manner presented is unique and helps student to remember for exam which is the first of its kind.

Chapter 26 to 28, Isomerism and detailed description of optical and geometrical isomerism is presented in a simplified manner.

Chapter 29 to 30, Heterocyclic rings of various types and their utility in pharmaceutical chemistry is described well. The medicinal compounds derived from each heterocycles also exemplified which makes the reader inspiring.

In **Chapter 31,** Important reactions and reagents used in organic chemistry and some of the special reactions are described with their mechanism and applications in Pharmaceutical organic chemistry.

To inspire the readers and make them attracted, interesting facts about great scientists and Organic compounds and their discovery etc are given under each chapters.

In order to help students to remember well and reproduce well in exams, the style and presentation are followed simple and similar pattern in all chapters. We have also used some special abbreviations like **"CAD"** (which helps to remember cold Alkaline dilute).

To help the students to learn and magnetize the attention we have used color in equations and diagrams. We have done it this thoughtfully and purposefully and not just to make the book attractive. These small inputs helps a lot for the fresher's who enter into degree program.

We hope that this special volume will be a good source of information and reference for not only to graduates and post-graduate students but also for basic and applied researchers in this field. Moreover it will also be of interest to a wide range of scientists who are involving in the Pharmaceutical organic chemistry related research. I welcome suggestions and constructive criticism from all corners of scientific community.

V. Alagarsamy
drvalagarsamy@gmail.com

What is the best way to study organic chemistry?

- Develop the desire to study organic chemistry
- Read the basic points thoroughly
- Read the chemical structures and correlate with the basics studied
- Be through with the nomenclature
- Always prepare your own notes by applying the above knowledge
- Read each and every step of the reaction and mechanism thoroughly
- Practice daily
- Make use of the lab time
- Discuss in a group and clear the doubts spontaneously
- Break large tasks in smaller ones

Acknowledgement

A warm response to my earlier Books on the "Text Book of Medicinal Chemistry", "Pharmaceutical Chemistry of Natural Products" (Published by Elsevier), Pharmaceutical Inorganic Chemistry (Published by Pharma Book Syndiacte) prompted me to write this Book on "Pharmaceutical Organic Chemistry", covering all the topics suggested by the Pharmacy Council of India (PCI) for graduate students. I dedicate this book to the many hundreds of budding graduates and pharmacy students, whom I have taught over the years and my Teachers who have encouraged me to convert my class notes into the text book in order to reach into wide range of academic community.

It is my pleasure to place on record my heartfelt thanks to everyone who have made this book possible, especially my beloved teachers of 10+2 class to Ph.D., who made me to read the Organic Chemistry in a simplified manner while the other students felt difficulty in reading and reproducing in the Exams.

I am immensely grateful to Prof. K. Chinnaswamy, Dr. B. Suresh (President, Pharmacy Council of India) and Dr. R.K. Goyal, Dr. Rajani Giridhar, Dr. M.R. Yadav, Dr. C.J. Shishoo and Dr. U.S. Pathak for their constant support, inspiration and initiation extended to me to author this book.

I gratefully acknowledge the constant and continuous encouragement and moral support extended by Shri M.N. Raju, Chairman, and Mr. M. Ravi Varma, Vice Chairman, MNR Educational Trust, Hyderabad, for my entire academic and research pursuit, is a great motivation for me in taking up this new challenge.

I thank Prof. R. Shyam Sunder and Dr. Kavita Waghray Faculty of technology, Osmania University, Hyderabad for their constant support in all my academic activities.

I express my sincere appreciation to my students, research scholars and friends especially, Dr. V. Raja Solomon (Postdoctoral Research Associate, Laurentian University, Canada), Dr. G. Saravanan, Mrs. M.T. Sulthana, Mr. B. Narendhar, Mrs. K. Lahari and Dr. P. Subhash Chandra Bose for their support in making this book.

I thank Mr. Anil Shah, Managing Director, PharmaMed Press for recognising and inviting me to write this book. The friendly interaction experienced with the Pharma Book Syndicate, Mr. Naresh (Production Manager) and his team offered a cordial support, which always made me furnish my inputs to make this Book one of the Best. Getting such a cooperative and energetic team encourage the author to continue their writing always. I thank them whole heartedly for accepting all views while designing the book and helping me reach this target.

I also express my sincere thanks to my father-in-law (Shri. V. Sundara Rajan) and mother-in-law (Ms. S. Chinnammal) for their kind encouragement and moral support throughout my Career. My father-in-law born in a small village, studied upto 10th class only, had joined as a Police and came up to the level of Police Inspector is a great motivation for me.

In all my academic efforts the stimulation I gain from my father (Mr. P. R. Veerachamy), mother (Ms. V. Kamuthai), sister, brothers and wife A. Sathyabhama to reach this goal is like the nature provides sunlight for photosynthesis for healthy maintenance of humans, and the patience and cooperation extended by my children, A. Dharshini Aishwarya (B.Pharm) and A. Dharshini Abhinaya made me think of the goal without any diversion. To express my thankfulness, I pray the Almighty to bless my children with teachers like those I got in my life so that they too are inspired by their teachers and dedicate to the field of Pharmacy and, in turn, serve for the mankind.

V. Alagarsamy
drvalagarsamy@gmail.com
WhatsApp: +91 7674893936

Contents

Preface (vii)
Acknowledgement (xi)

1. Introduction to Organic Chemistry
Origin of Organic Chemistry 1
The Vital Force Theory "Essence of Life" 1
Definition of Organic Chemistry 2
Reasons for Treating Organic Chemistry as a Separate Branch of Chemistry 2
Rise of Organic Chemistry 5
Need for Studying Organic Chemistry 5
Classification of Organic Compounds 6
Organic Chemistry in the Service of Mankind 8
Probable Questions 8

2. Nomenclature of Organic Compounds
Introduction 9
IUPAC System of Nomenclature 9
- Steps Involved in Writing IUPAC name of the Compound 16
- Writing the Structural Formula from the given IUPAC Name 18

Probable Questions 19

3. Structure of Organic Molecules and their Relative Properties
Introduction to Atom/Molecule 21
- Wave Nature of Electrons and Wave Equations 21

Quantum Mechanics 23
Atomic Orbitals Involved in Organic Molecules 23
Shells, Sub-Shells and Orbitals 24
Quantum Numbers 24
Shapes of Atomic Orbitals 26
- Shape of *s* Orbital 26
- Shape of *p* Orbital 26

Rules for Distribution of Electrons into various Shells, Subshells and Orbitals 27
Probable Questions 28

4. Bonds in Organic Compounds
Introduction 31
The Nature of Bond between Atoms 31
- Types of Bonds 31
- Ionic Bond or Electrovalent Bond 31
- Covalent Bond 31
- Co-Ordinate Covalent Bond or Dative Bond 31

Electronic Theory of Valency 35
Characteristic Property of Covalent Bond 35
- Bond Length 35

Bond Angle 36
- Bond Energy 37

Bond Breaking 38
Bond Order 38
Polarity of Bond and Dipole Moments 38
Types of Orbital Overlapping and their Orbital Diagrams 39
- *s-s* Overlapping 39
- *s-p* Overlapping 40
- *p-p* Overlapping 40

Hybridization 41
- Salient Features of Hybridization 41
- Conditions for Hybridization 41

Theory of Hybridization for the Formation of Covalent Bond (Sidwick – Powell Theory) 41
Source of Energy required for Hybridization 42
Types of Hybridization 42
- sp^3 Hybridization or Tetrahedral Hybridization 42
- sp^2 Hybridization or Trigonal Hybridization 43
- *sp* Hybridization or Diagonal Hybridization 44

Effectiveness of Overlap 45
Molecular Orbital Theory 45
Probable Questions 46

5. Factors Influencing a Chemical Reaction or Electronic Displacements in Molecules
Introduction 49
Inductive Effect 49
- Types of Inductive Effect 50

Mesomeric and Resonance Effect 50
- Types Mesomeric Effect 51

Electromeric Effect 52
- Types of Electromeric Effect 53

Resonance 53
Hyperconjugation 55
Probable Questions 55

6. Organic Reactions and Mechanism

Introduction 57
Bond Breaking (Homolysis and Heterolysis) 57
Homolysis 57
Heterolysis 58
Organic Reagents (Nucleophiles and Electrophiles) 58
Nucleophiles (Nucleous Loving Species or Electron Rich Species) 58
Electrophiles (Electron Loving Species or Electron Deficient Species) 58
Types of Organic Reactions 59
Substitution Reactions 59
Addition Reactions 60
Elimination Reactions 61
Rearrangement Reactions 61
Reaction Mechanisms 62
Reactive Intermediates or Reaction Intermediates 62
Carbonium Ions or Carbocations 63
Carbanions 65
Carbon Free Radicals 65
Carbenes 67
Nitrenes or Imidogens 68
Vinylamines or Enamines or α,β-Unsaturated Amines 68
Probable Questions 69

7. General Terms used in Organic Chemistry

General Terms Like Homologues Series 71

8. Alkanes

Introduction 99
Importance of Alkanes 99
Nomenclature of Alkanes 100
General Methods of Preparation 104
Summary of General Methods of Preparation of Alkanes 107
Physical Properties 108
Structure 108
Chemical Properties 108
Summary of Chemical Reactions 114
Pyrolysis or Cracking of Alkanes 114
Probable Questions 115

9. Alkenes or Olefins

Introduction 117
Importance of Alkenes 117
Nomenclature 119
Isomerism 120
General Methods of Preparation 120
Summary of Methods of Preparation 123
Structure 123
Physical Properties 124
Chemical Properties of Alkenes 124
Summary of Reactions of Alkenes 138
Probable Questions 139

10. Alkadienes or Dienes or Diolefins

Introduction 141
Importance of Alkadienes 141
Nomenclature 142
Butadiene 144
Summary of Methods of Preparation 145
Relative Stability of Dienes 145
Stability of Conjugated Dienes 146
Summary of Chemical Reactions 155
Theory of Resonance 155
Resonance Stabilisation of Allyl Radicals - Hyper Conjugation 157
Allyl Cation as a Resonance Hybrid 157
Nucleophilic Substitution in Allylic Substrates: S_N1 Reactivity and Allylic Rearrangement 158
Nucleophilic Substitution in Allylic Substrates 159
S_N2 Reaction 159
Free Radical Addition Reactions of Conjugated Diene 159
Probable Questions 161

11. Cycloalkanes

Introduction 163
Importance of Cycloalkanes 163
Nomenclature 164
General Methods of Preparation 165
Physical Properties 167
Chemical Properties 167
Summary of Chemical Reactions 169
Bayer's Strain Theory or Stability of Cycloalkanes or Ring Strain 170
Molecular Orbital Theory of Cycloalkanes 171
Type of Strains 172
Sache-Mohr Theory 172
Structure of Two Forms of Cyclohexane 172
Axial Hydrogens 173
Equatorial Hydrogens 173
Conformations of Cycloalkanes 173
Drawing Chair Form of Cyclohexane Ring 173
Interconversion of Conformations of Cyclohexane 175
Conformations of Mono Substituted Cyclohexanes 175

Conformations of Disubstituted Cyclohexanes 176
Coulson and Moffit's Theory of Maximum Overlapping of Carbon Orbitals 177
Probable Questions 177

12. Alcohols

Introduction 179
Importance of Alcohols 179
Monohydric Alcohols 181
Introduction 181
Classification 181
Nomenclature 182
General Methods of Preparation 183
Summary of Methods of Preparation 188
Physical Properties 189
Chemical Properties 189
Structure 189
Reactions Involving Replacement of Hydrogen of the Hydroxyl Group 190
Reactions Involving Replacement of Hydroxyl Group 191
Reactions Involving both Alkyl Group and Hydroxyl Group 192
Chemical Tests for Alcohols 193
Distinction between Primary, Secondary and Tertiary Alcohols 194
Summary of Chemical Reactions 196
Dihydric Alcohols (or) Diols 197
Introduction 197
Nomenclature 197
Trihydric Alcohols (or) Triols 197
Introduction 197
Pharmaceutically Important Alcohols 198
Nitroglycerin 198
Unsaturated Alcohols 199
Vinyl Alcohol 199
Allyl Alcohol 199
Pharmaceutical Importance of alcohols
Benzyl alcohol - 200
Cetostearyl alcohol - 200
Chlorbutol - 200
Ethanol - 200
Glycerol - 200
Propylene - 201
Methanol - 201
Qualitative Tests for Alcohols 201
Probable Questions 202

13. Halogen Derivatives or Alkyl Halides

Introduction 205
Importance of Alkyl Halides 205
Classification 206
Nomenclature 207
General Methods of Preparation 208
Summary of Methods of Preparation 212
Structure 213
Physical Properties 213
Chemical Properties 214
Nucleophilic Substitution Reactions 215
Elimination Reactions 215
Miscellaneous Reactions 222
Summary of Chemical Reactions 224
Nucleophilic Substitution Reactions 224
Structure and Uses of
Ethylchloride 225
Chloroform 225
Trichloroethylene or Trilene 225
Tetrachloroethylene or Perchloro Ethylene 225
Dichloromethane or Methylene Dichloride 225
Tetrachloro Methane or Carbon Tetrachloride 225
Iodoform or Triodomethane 226
Probable Questions 226

14. Nucleophilic Substitution and Elimination Reactions

Introduction 227
Components of Nucleophilic Substitution Reaction 227
Mechanisms 227
The S_N2 Mechanism 227
Stereochemistry of S_N2 Reaction 229
Factors Affecting S_N2 Reactions 230
First Order Nucleophilic Substitution Reaction (S_N1) or Unimolecular Nucleophilic Substitution Reaction 238
Stereochemistry of S_N1 Reactions 240
Factors Affecting S_N1 Mechanism 241
Carbocation Rearrangement in S_N1 Reaction 244
Competition between S_N2 and S_N1 244
Comparison between S_N1 and S_N2 Reactions 245
Elimination Reactions 246
Introduction 246
E_2 Mechanism or β-elimination 246
Zaitsev's Rule 249
Stereochemistry of E_2 Reaction 252
E_1 Reaction or Unimolecular Elimination Reaction 254
Stereochemistry of E_1 Reaction 255
Competition between Substitution and Elimination Reactions 256
Conditions for S_N2/ E_2 257

Conditions for S_N1/E_1 257
Elimination Reactions from Cyclic Compounds 258
E_2 Elimination from Cyclic Compounds 258
E_1 Elimination from Cyclic Compounds 258
Consecutive E_2 Elimination Reactions 259
Evidence of E_2 Mechanism 259
Phase Transfer Catalysis 261
Probable Questions 263

15. Aldehydes and Ketones

Introduction 265
Importance of Aldehydes and Ketones 265
Industrial Importance of Aldehydes and Ketones 267
Nomenclature of Aldehydes 267
Nomenclature of Ketones 267
General Methods of Preparation of Aldehydes and Ketones 269
Summary of Methods of Preparation 275
Physical Properties 277
Chemical Properties 278
Nucleophilic Addition Reactions 278
Addition-Elimination Reactions 289
Oxidation Reactions 293
Reduction Reactions of Aldehydes and Ketones 294
Condensation Reactions 297
Applications of Cannizaro Reactions 303
Some of the Reactions of Aldehydes which are not given by Ketones 305
Summary of Chemical Reactions 306
Chemical Reactions of Aldehydes 306
Chemical Reactions of Ketones 307
Pharmaceutical Importance of
Formaldehyde 309
Chloral Hydrate 309
Paraldehyde 309
Hexamine 309
Benzaldehyde 310
Cinnamaldehyde 310
Acetone or Dimethyl Ketone 310
Vanillin 310
Identification Test for Aldehydes and Ketones 310
Probable Questions 312

16. Carboxylic Acids

Introduction 313
Importance of Carboxylic Acids 313
Nomenclature of Carboxylic Acids 314
Mono Carboxylic Acids or Fatty Acids 316
General Methods of Preparation 316
Summary of Methods of Preparation 320
Structure 321
Physical Properties 321
Chemical Properties 322
Acidity of Carboxylic Acids 325
Effect of Substituents on Acidity 326
Determination of Acidity Constant or Acidity of Carboxylic Acids 327
Summary of Chemical Reactions 333
Higher Fatty Acids 334
Palmitic Acid 334
Stearic Acid 334
Unsaturated Monocarboxylic Acids 334
Oleic Acid 334
Pharmaceutical Importance of Carboxylic Acids
Acetic Acid 334
Lactic Acid 334
Citric Acid 334
Succinic Acid 334
Oxalic Acid 335
Salicylic Acid 335
Aspirin 335
Methyl Salicylate 335
Benzoic Acid 335
Benzyl Benzoate 335
Dimethyl Phthalate 336
Tartaric Acid 336
Qualitative Test for
Carboxylic Acids 336
Esters 337
Amides 337
Amines 337
Probable Questions 338

17. Fats and Oils

Introduction 339
Occurence of Lipids 339
Biological Functions of Lipids 339
Classification of Lipids 339
Simple Lipids (Fats and Oils) 340
Differences between Fats and Oils 340
Nomenclature of Fats 341
Extraction of Fats 342
Rendering 342
Solvent Extraction 342
Refining 342

Physical and Chemical Properties of Fats and Oils 342
Analysis of Oils and Fats 344
Physical Constants 344
Chemical Constants 345
Acid Value 345
Saponification Value 345
Ester Value 345
Acetyl Value 345
Iodine Value 346
Reichert Meissl Value (or) RM Value 346
Polenski Value 346
Fatty Acids 346
Nomenclature of Fatty Acids 346
Classification of Fatty Acids 347
Isomerism in Unsaturated Fatty Acids 348
Reactions of Fatty Acids 349
Probable Questions 350

18. Amines, Alkyl Nitrites and Alkyl Nitrates
Introduction 351
Importance of Amines 351
Nomenclature 353
General Methods of Preparation 355
Separation of Mixture of Amines 361
Fractional Distillation 361
Hoffmann's Method 362
Summary of Methods of Preparation 363
Preparation of Primary Amines 363
Preparation of Secondary Amines 364
Preparation of Tertiary Amines 364
Structure 364
Physical Properties 365
Basicity of Amines 365
Chemical Properties 367
Summary of Chemical Reactions of Primary Amines 371
Ascent and Descent of Series 372
Pharmaceutical Importance of
Amphetamine 372
Ethanolamine 373
Ethyene Diamine 373
Probable Questions 373

19. Introduction to Aromatic Compounds
Introduction 375
Reasons for Separate Classification of Aromatic Compounds 375
Nomenclature of Aromatic Compounds 375
Orientation 378
Reactions of Substituted Benzene 381
Effect of Substituents on Reactivity 381
Relative Reactivity of Substituted Benzene 383
The Effect of Substituents on Orientation 389
Summary 392
Electrophilic Aromatic Substitution of Disubstituted Benzene 392
Probable Questions 393

20. Benzene and its Analogues (Arenes)
Introduction 395
Importance of Benzene 395
The Great Discovery of Benzene (A Shining Molecule) 396
Criteria for Aromaticity 397
Structure of Benzene (Kekule's Structure of Benzene) 397
Bonding in Benzene 400
Unusual Stability of Benzene or Resonance Energy of Benzene 401
Resonance Energy 402
The Molecular Orbital Structure of Benzene 403
Representation of Molecular Orbital Structure of Benzene 403
The Energy Diagram of Benzene 405
Huckel's Rule or Concept of Aromatic Character (Aromaticity) 406
Theoretical Criteria for Aromaticity 406
Relationship between Some Aromatic Compounds and their Similar Open Chained Molecule 408
General Methods of Preparation of Benzene and its Analogues 412
Summary of Methods of Preparation 416
Summary of Methods of Preparation of Homologues of Benzene 417
Physical Properties of Benzene 418
Chemical Reactions of Benzene 418
Summary of Chemical Reactions 439
Annulenes 441
Structure and Uses of Medicinal Important Compounds
DDT 442
Saccharine 442
BHC 442
Chloramine-T 442
Probable Questions 442

21. Aromatic Amines

Introduction 445
Importance of Aryl Amines 446
Nomenclature 448
Primary Amino Compounds 448
  General Methods of Preparation 448
Summary of Methods of Preparation 453
  Physical Properties 453
  Chemical Properties 454
  Basicity of Amines 462
Summary of Chemical Reactions 463
Tests for Distinguishing Primary, Secondary and Tertiary Amines 465
Probable Questions 466

22. Aryl Diazonium Salts

Introduction 467
  Preparation 467
  Physical Properties 467
  Chemical Properties 468
Summary of Chemical Reactions 476
Probable Questions 477

23. Phenols

Introduction 479
Importance of Phenols 480
Phenol 481
  Preparation 481
Summary of Methods of Preparation 483
  Physical Properties 483
  Chemical Properties 484
  Acidity of Phenols 484
Summary of Chemical Reactions 496
  Uses of Phenol 499
  Tests for Identification 500
Homologues of Phenol 500
  Methyl Phenols (Cresols) 500
Dihydric Phenols 500
  Catechol 501
  Resorcinol 501
  Quinol 501
Trihydric Phenols 502
  Pyrogallol 502
  Hydroxyl Quinol 503
  Phloroglucinol 503
Aromatic Alcohols 504
  Benzyl Alcohol (Phenyl Methanol) 504
Amino Phenols 504
Aromatic Ethers 504
Structure and Medicinal uses of
  Phenol 505
  Cresols 505
  Resorcinol 505
  Naphthols 505
Probable Questions 506

24. Aromatic Carboxylic Acids and their Derivatives

Introduction 509
Importance of Aryl Carboxylic Acids 509
Nomenclature 511
General Methods of Preparation 511
Summary of Methods of Preparation 514
  General Properties 514
Individual Members 514
  Benzoic Acid 514
Summary of Chemical Reactions 519
  Chemical Test for Benzoic Acid 519
  Comparison of Benzoic Acid and Phenol 520
  Acidity of Aromatic Carboxylic Acids 520
Probable Questions 520

25. Polynuclear Hydrocarbons

Introduction 523
  Types 523
Naphthalene 523
  Manufacture of Naphthalene 523
  Synthesis 524
  Physical Properties 525
  Chemical Properties 525
  Uses 530
Anthracene 531
Preparation of Anthracene 531
  Synthesis 531
  Physical Properties 532
  Chemical Properties 532
  Uses 534
Phenanthrene 536
  Preparation 536
  Isolation 536
  Synthesis 536
  Physical Properties 536
  Chemical Properties 537
  Uses 538
Diphenyl Methane 539
  General Methods of Preparations 540
  Chemical Properties 540
  Uses 541

Triphenyl Methane or Tritane 542
General Methods of preparations 542
Physical Properties 543
Chemical Properties 543
Uses 543
Probable Questions 544

26. Isomerism

Introduction 545
Types of Isomerism 545
Structural Isomerism or Constitutional Isomerism 546
Tautomerism 549
Stereoisomerism 551
Probable Questions 552

27. Stereoisomerism

Introduction 553
Optical Isomerism 553
Chiral Carbon 555
Enantiomers 555
Diastereomers 556
Meso Compounds 557
Chirality and Symmetry of Elements 558
Chiral Molecules 559
Achiral Molecules 560
DL System of Nomenclature 560
Nomenclature of Enantiomers or
RS Nomenclature of Optical Isomers 562
Sequence Rules 562
Reactions of Chiral Molecules 567
Racemic Modification 572
Mechanism of Racemisation 572
Walden Inversion 573
Resolution or Separation of Racemic Mixture 573
Asymmetric Synthesis 575
Probable Questions 576

28. Geometrical Isomerism

Introduction 577
Nomenclature of Geometrical Isomers 579
Determination of Configuration of
Geometrical Isomers 581
Conformations of Alkanes 588
Conformational Isomerism in Ethane 589
Conformational Isomerism in *n*-Butane 590
Conformations of Cycloalkanes 592
Drawing Chair form of Cyclohexane Ring 592
Interconversion of Conformations of
Cyclohexane 594
Conformations of Mono Substituted
Cyclohexanes 594
Conformations of Disubstituted Cyclohexanes 595
Stereoisomerism in Biphenyl Compounds 596
Conditions for Biphenyls to show Optical Isomerism 597
Conditions for Optical Activity 598
Stereoselective and Stereospecific Reactions 598
Probable Questions 601

29. Heterocyclic Compound (Part 1)

Introduction to Heterocyclic Compounds 603
Pharmaceutical Applications of
Heterocyclic Compounds 604
Nomenclature of Heterocyclic Compounds 607
Classification of Heterocyclic Compounds 611
Pyrrole (Azacyclopenta-2,4-diene) 618
Introduction 618
Isolation 618
General Methods of Preparation 618
Structure 619
Physical Properties 620
Chemical Properties 621
Basic Nature of Pyrrole 621
Acidity of Pyrrole 621
Pyrrole Derivatives 626
Medicinal Compounds Containing Pyrrole (or)
Pyrrole Derivatives Used in Medicine 627
Furan/Furfuran (Oxacyclopenta-2,4-diene) 628
Introduction 628
Isolation 629
General Methods of Preparation 629
Structure 629
Physical Properties 630
Chemical Properties 630
Furan Derivatives 634
Tetra Hydro Furan(THF)/
Oxolane/Oxacyclopentane 634
Medicinal Compounds Containing Furan (or)
Furan Derivatives Used in Medicine 638
Thiophene (Thiocyclopenta-2,4-diene) 639
Introduction 639
Isolation 640
General Methods of Preparation 640
Structure 641
Physical Properties 641
Chemical Properties 641

Medicinal Compounds Containing Thiophene (or) Thiophene Derivatives Used in Medicine 646
Relative Aromaticity and Reactivity of Pyrrole, Furan and Thiophene 647
Probable Questions 648

30. Heterocyclic Compounds (Part 2)

Azoles 649
Types of Azoles 649
Structure of all Azoles 650
Pyrazole 650
General Methods of Preparation 651
Synthesis of Substituted Pyrazoles 651
Physical Properties 652
Chemical Properties 652
Medicinal Compounds Containing Pyrazole (or) Pyrazole Derivatives used in Medicine 654
Imidazole (iminazoline) 655
General Methods of Preparation 655
Synthesis of Substituted Imidazoles 656
Physical Properties 656
Chemical Properties 656
Medicinal Compounds Containing Imidazole (or) Imidazole Derivatives used in Medicine 658
Oxazole 661
General Methods of Preparation 661
Synthesis of Substituted Oxazole 661
Chemical Properties 662
Medicinal Compounds Containing Oxazole Derivatives used in Medicine 663
Thiazole 663
General Methods of Preparation 664
Physical Properties 664
Chemical Properties 664
Medicinal Compounds Containing Thiazole (or) Thiazole Derivatives used in Medicine 665
Six Membered Heterocycles with One Hetero Atom 666
Pyridine 666
Nomenclature 666
Structure of Pyridine 667
General Methods of Preparation 668
Chemical Properties 669
Medicinal Compounds Containing Pyridine (or) Pyridine Derivatives used in Medicine 673
Quinoline (1-Azanaphthalene or Benzopyridine) 676
Introduction 676
General Methods of Preparation 677
Physical Properties 678
Structure 678
Chemical Properties 679
Medicinal Compounds Containing Quinoline (or) Quinoline Derivatives used in Medicine 683
Isoquinoline (2-Azanaphthalene (Or) Benzo[b]Pyridine) 684
General Methods of Preparation 684
Physical Properties 686
Chemical Properties 686
Medicinal Compounds Containing Isoquinoline (or) Isoquinoline Derivatives used in Medicine 688
Acridine 689
General Methods of Preparation 690
Physical Properties 691
Chemical Properties 691
Medicinal Compounds Containing Acridine (or) Acridine Derivatives used in Medicine 692
Indole (1*H*-1-Azaindine/Benzopyrrole) 693
General Methods of Preparation 693
Structure 695
Physical Properties 695
Chemical Properties 695
Indole Derivatives 700
Medicinal Compounds Containing Indole (or) Indole Derivatives used in Medicine 702
Pyrimidine 703
General Methods of Preparation 703
Medicinal Compounds Containing Pyrimidine (or) Pyrimidine Derivatives used in Medicine 703
Purine 706
General Methods of Preparation 707
Medicinal Compounds Containing Purine (or) Purine Derivatives used in Medicine 708
Azepines 710
General Methods of Preparation of Azepine and its Derivatives 710
Medicinal Compounds Containing Azepine (or) Azepine Derivatives used in Medicine 711
Probable Questions 712

31. Reactions and Reagents of Synthetic importance

Sodium Borohydride ($NaBH_4$) 713
Method of Preparation 713
Advantages 713
Applications 713
Lithium Aluminium Hydride ($LiAlH_4$) 714
Preparation 714
Properties 714
Advantages 715
Applications 715

Clemmensen Reduction 718
Mechanism 719
Applications 719
Birch Reduction 720
Mechanism 720
Applications 720
Effect of Substituents on Birch Reduction 721
Wolff Kishner Reduction 721
Mechanism 722
Applications 722
Oppaneur-Oxidation 723
Mechanism 723
Applications 724
Dakin's Reaction 725
Mechanism 725
Applications 725
Beckmann Rearrangement 726
Mechanism 726
Applications 727
Schmidt Rearrangement 727
Mechanism 727
Applications 729
Claisen-Schmidt Condensation 729
Mechanism 729
Applications 730
Probable Questions 731

Index 733

2

Nomenclature of Organic Compounds

Introduction

In early days, scientists named the compounds based on historic background. For example, "wood spirit" was named so because it was obtained from distillation of wood. Later it was named as methanol based on Greek words (methu = wine and hale = wood). Similarly, the name "acetic acid" was derived from vinegar (Latin; acetum = vinegar), because the acetic acid is the major constituent of vinegar. These are called as common names or trivial names.

As the number of compounds were discovered more, naming by history becomes difficult. Hence systematic naming becomes important. The systematization of names was carried out by the International congress of leading chemistry held in Geneva, 1892.

Rational system of nomenclature was formed and it is called as Geneva system of nomenclature. Slight revision and improvements were carried out time to time. One such being held at Liege (Belgium) 1930 by International Union of Chemistry and it is called as IUC system of nomenclature. The IUC was later modified by the International Union of Pure and Applied Chemistry in 1958 and it is called as IUPAC system of nomenclature.

To name the organic compound according to IUPAC nomenclature a set of rules were framed and all the compounds are named accordingly. However, even today some of the common names are used for organic compounds. Hence the chemists should also be aware of the common names apart from IUPAC nomenclature.

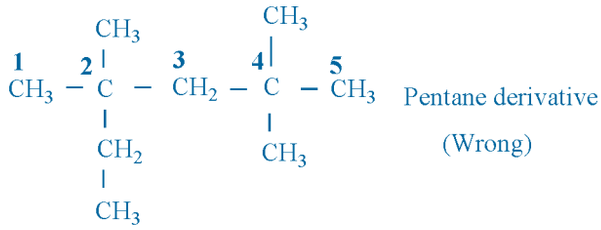
Non-systemic nomenclature of organic compounds like common name, trivial name *etc* are described in individual chapters.

IUPAC System of Nomenclature

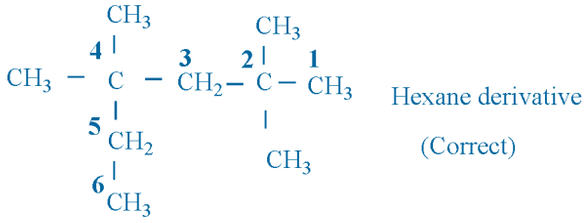
IUPAC nomenclature is been used now a days to name organic compounds. However, some of the simple compounds are named by trivial names. Earlier names have been continued even today but complex organic compound can be given using IUPAC nomenclature only. Various rules are followed for naming compounds by IUPAC system:

Rule 1: Longest chain rule: "In the given organic compound longest possible chain of carbon atoms is selected and the compound is named as a derivative of this alkane."

For example, the compound given below have five carbons in horizontal line and six carbons in the longest chain hence we should select it as a hexane derivative only.



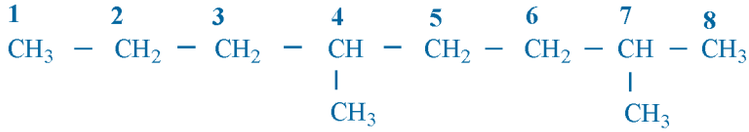
Pentane derivative (Wrong)



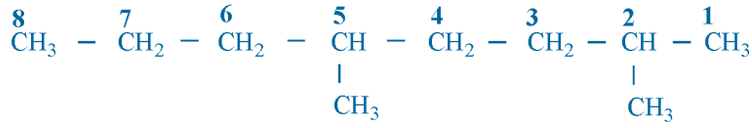
Hexane derivative (Correct)

Rule 2: Lowest number for substituents rule: After selecting the longest chain, the numbering should be given from one end to the other end. While giving the number, the substituents should be given lowest possible number.

For example, the compound given below is named in two ways.



4,7-Dimethyl octane (Wrong)

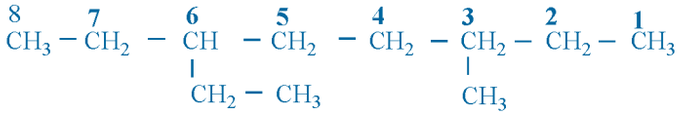


2,5-Dimethyl octane (Correct)

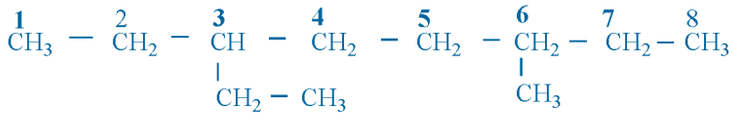
In first case, naming 4,7-dimethyl octane is not correct because 2,5-di methyl octane have lowest numbers for the substituents.

If different alkyl groups are in equivalent positions in relation to the end of the chain, preference is given to the end where the radical has fewer carbon atoms (methyl, ethyl, *etc*).

In the following example, the first case of naming is correct because methyl group is given preference over ethyl group.



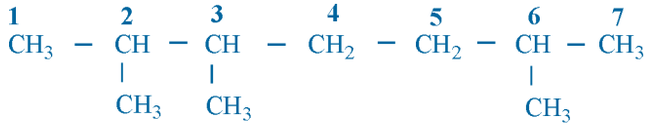
6-Ethyl-3-methyl octane (Correct)



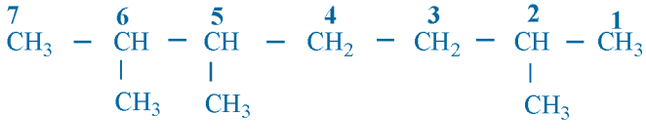
3-Ethyl-6-methyloctance (Wrong)

If identical radicals are at equal distance in the chain then the numbering starts from the end where it is more branched.

In the following example, the first way of naming is correct where the branching end is given preference.



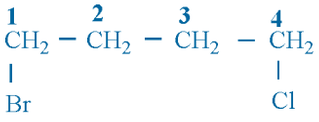
2,3,6-Trimethyl heptane (Correct)



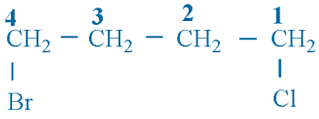
2,5,6-Trimethyl heptane (Wrong)

If two sets of numbers are possible for the given chain, then order of prefix in the name will decide the numbering (alphabetical order of the substituents).

For example, the given compound can be named as 1-bromo-4-chloro butane or 1-chloro-4-bromo butane. As the prefix bromo is first, the first name is correct.



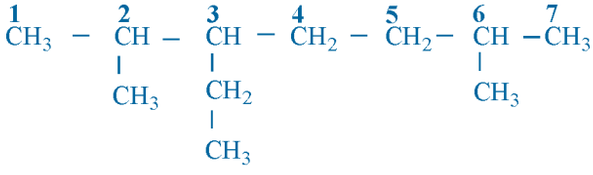
1-Bromo-4-chloro butane (Correct)



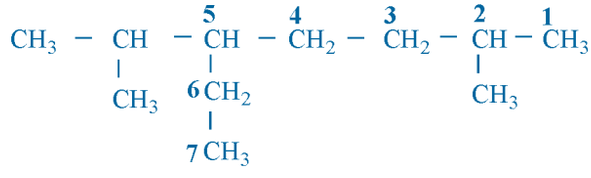
1-Chloro-4-bromo butane (Wrong)

If chains of equal length are competing for selection as the parent chain in a branched alkane, the preference goes to the chain carrying more branches.

For example, in the given organic compound first way of naming *i.e.,* 3-ethyl-2,6-dimethyl heptane is correct where as 5-isopropyl-2-methyl heptane is wrong.



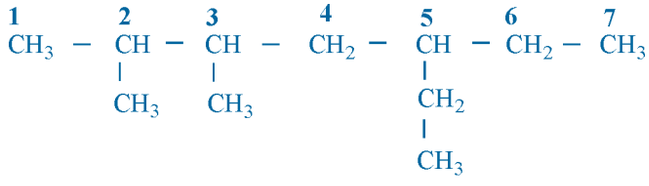
3-Ethyl-2,6-dimethyl heptane (Correct)



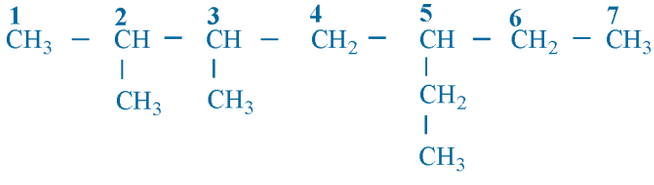
5-Isopropyl-2-methyl heptane (Wrong)

Rule 3: Arrangement of prefixes: When there is more than one group attached in the chain, they should be arranged alphabetically. If same group is presented in two or three places of chain then the prefix di or tri *etc* are used.

For example, the given organic compound is named as 5-ethyl-2,3-dimethyl heptane.

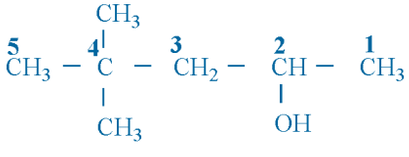


5-Ethyl-2,3-dimethyl heptane (correct)

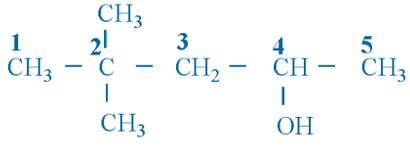


2,3-Dimethyl-5-ethyl heptane (wrong)

Rule 4: Lowest number for functional group: When the functional group is present in the chain, it should be given first preference even if it violates lowest number rule 2. Double bond or triple bond also considered as functional groups.



4,4-Dimethyl-2-pentanol (Correct)



2,2-Dimethyl-4-pentanol (Wrong)

The order of preference of numbering is as follows.

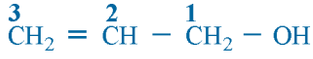
(i) To the principal functional group of a compound.
(ii) To the double or triple bond.
(iii) To the substituent atoms or groups.

When more than one functional group present in the compound, then the order of preference is as follows.

1. Carboxylic acids
2. Carboxylic acid derivatives
3. Aldehydes
4. Nitriles
5. Ketones

6. Alcohols
7. Amines
8. Ethers
9. Olefins
10. Acetylenes

Systematic name for allyl alcohol is



2-Propene-1-ol

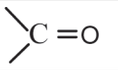
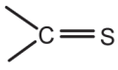
For nomenclature purpose the following functional groups are considered as substituents not as functional groups (halo, nitroso and azo as they do not have ending).

When there is more than one functional group in the compound, one is principal functional group and the other is secondary functional group. The prefixes and suffixes used for various functional groups are depicted in the following Table 2.1.

Table 2.1 Groups cited only as prefixes.

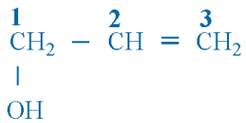
S. No.	Functional Group	*Prefix* name
1.	– F	Fluoro
2.	– Br	Bromo
3.	– Cl	Chloro
4.	– ClO	Chlorosyl
5.	– ClO_2	Chloryl
6.	– ClO_3	Perchloryl
7.	– I	Iodo
8.	=N_2	Diazo
9.	– N_2	Azido
10.	– NC	Carbylamino
11.	– NO	Nitroso
12.	– NO_2	Nitro
13.	– N(O)OH	*aci*-Nitro
14.	– OR	Alkyl or aryl-oxy
15.	– SR	Alkyl-thio
16.	$-OC\equiv N$	Cyanato
17.	– OOH	Hydroperoxy
18.	– OR	Alkyl-oxy
19.	– OOR	Alkyl-dioxy
20.	$-S-C\equiv N$	Thiocyanato
21.	– SR	Alkyl-thio
22.	– S(O)R	Alkyl-sulphinyl
23.	– SO_2R	Alkyl-sulphonyl
24.	– SSR	Alkyl-dithio
25.	$-N=C=O$	Carbonylamino
26.	$-N=C=S$	Thiocarbonylamino

Table 2.2 Groups cited as prefixes or suffixes.

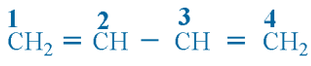
S. No.	Functional Group	*Prefix* name	*Suffix* Name
1.	—COOH	Carboxy	Carboxylic acid
2.	– SO_2 OH	Sulpho	– sulphonic acid
3.	—COX	---	– oyl(-yl) halide
4.	—$CONH_2$	Carbamoyl	– carboxamide or amide
5.	—C≡N	Cyano	– nitrile
6.	$\overset{\oplus}{-}N\equiv\overset{\ominus}{C}$	Cyano	– Isonitrile
7.	—CHO	Formyl	– al
8.		Oxo	– one
9.		Thioxo	– thione
10.	—OH	Hydroxy	– ol
11.	—SH	Mercapto	– thiol
12.	$-NH_2$	Amino	– amine
13.	=NH	Imino	– imine

Rule 5: Writing names for compounds containing more than one functional group: Whenever more than one functional group are present in the given compound then the ending is suitably modified. Carbon – carbon multiple bonds and second functional groups are combined in endings or the important functional group is considered as substituent.

Some of the examples are shown below.



2-Propene-1-ol



1,3-Butadiene

Name of some compounds containing two or more functional groups are shown in Table 2.3.

Table 2.3 Nomenclature of some simple polyfunctional compounds.

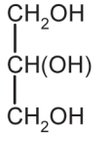
S. No.	Functional Groups	Generic name	Specific examples	
			Structure	Name
1.	Two hydroxyl	Alkanediol		Ethane-1,2-diol
2.	Three hydroxyl	Alkanetriol		1,2,3-Propane triol
3.	Two double bonds	Alkadienes	$CH_2{=}CH{-}CH{=}CH_2$	1,3-Butadiene

Table 2.3 *Contd...*

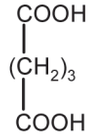
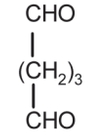
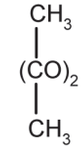
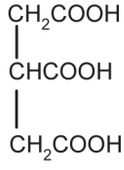
S. No.	Functional Groups	Generic name	Specific examples	
			Structure	Name
4.	Two acids	Alkanedioic acid		Pentanedioic acid
5.	Two aldehydes	Alkanedial		Pentanedial
6.	Two ketones	Alkanedione		2,3-Butanedione
7.	Three acids	Tricarboxylic acid		1,2,3-Propane tricarboxylic acid

Table 2.4 Nomenclature of some unsaturated compounds of Simple Functions.

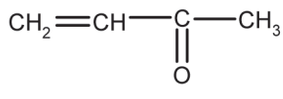
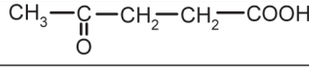
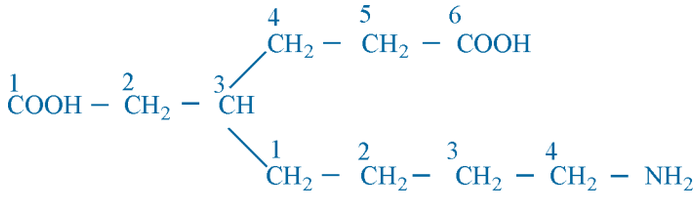
S. No.	Unsaturation and Functional Groups	Generic name	Specific examples	
			Structure	Name
1.	Double bond and acid	Alkenoic acid	$CH_2{=}CH{-}COOH$	Propenoic acid
2.	Triple bond and aldehyde	Alkynal	$CH{\equiv}C{-}CHO$	Propynal
3.	Double bond and ketone	Alkenone		3-Butene-2-one
4.	Two double bonds and alcohol	Alkadienol	$(CH_2{=}CH{-}CH_2)_2\,CHOH$	1,6-Hepatadien-4-ol
5.	Double bond and two hydroxyls	Alkenediol	$HOCH_2{-}CH{=}CH{-}CH_2OH$	2-Butene-1,4-diol

Table 2.5 Nomenclature of some compounds of complex Functions.

S .No.	Complex functional Groups	Generic name	Specific examples	
			Structure	Name
1.	Keto acid	Oxoalkanoic acid		4-Oxopentanoic acid
2.	Hydroxy acid	Hydroxy alkanoic acid	$HOCH_2{-}COOH$	Hydroxy ethanoic acid
3.	Amino acid	Amino alkanoic acid	$H_2N(CH_2)_5COOH$	6-Amino hexanoic acid
4.	Cyano acid	Cyano alkanoic acid	$N{\equiv}C{-}CH_2{-}COOH$	Cyano ethanoic acid
5.	Aminoketone	Aminoalkanone	$H_2N(CH_2)_2COCH_3$	4-Amino-2-butanone
6.	Alkoxy alcohol	Alkoxy alkanol	$CH_3O{-}CH_2{-}CH_2OH$	2-Methoxy ethanol

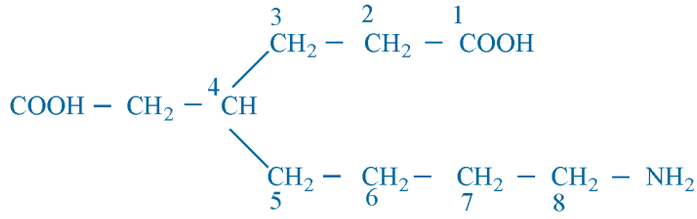
Rule 6: Treatment of "like things alike": All groups of one kind which occurs in a single molecule should be given the same treatment as far as possible.

For example, in the given example carboxylic acid is the main functional group, the parent compound should include two or three functional groups as possible.



3-(4-aminobutyl)hexane-1,6-dioic acid

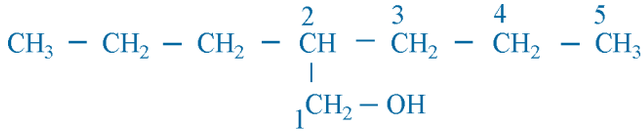
(Preferred)



8-Amino-4-(carboxyl methyl) octanoic acid

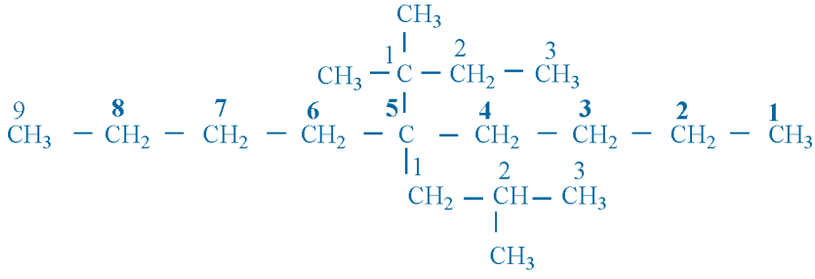
(Not preferred)

Rule 7: Functional groups and the selected chain: Maximum number of functional groups must be included in the carbon chain even if it violates longest chain rule (Rule 1), as shown in the following example.



2-Propyl-1-pentanol

When there is a side chain with side chain, the latter is numbered and the name of the complex is considered to start with the first letter of its complete name, as shown in the following example.



5-(1,1- Dimethylpropyl)-5-(2-methylpropyl) nonane

In addition to these rules, following points mentioned are also useful in writing IUPAC name of compound.

Steps involved in writing IUPAC name of the compound

Step 1: Locate the longest chain containing principal functional group and as many as secondary functional group and carbon-carbon multiple bonds.

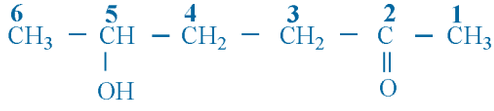
Step 2: Select the root word corresponding to the chain length. For example Hex for six carbon atom chain.

Step 3: Number the longest chain selected from the end near to the principal functional group.

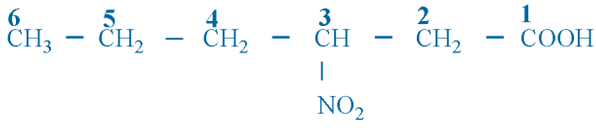
Step 4: Based on the carbon-carbon bonds $C-C$, $C=C$, $C\equiv C$ attach the suffix -ane, -ene or yne respectively to the root word of carbon chain.

Step 5: Add suitable prefixes and suffixes with numerals to indicate the number and position of each side chain, substituent, or functional group.

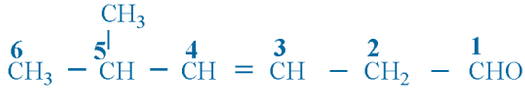
Example:



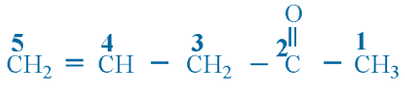
5-Hydroxy-2-hexanone



3-Nitrohexanoic acid



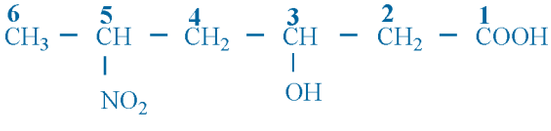
5-Methyl-3-hexen-1-al



4-Pentene-2-one

(or)

Pent-4-en-2-one



3-Hydroxy-5-nitro hexanoic acid

Notes:

1. **Position of numerals used in the enumeration of substituents:** Numerals representing location of unsaturation or functional groups are placed before the name stem as

2-Pentene	not pentene-2
1-Chloro-2-pentene	not 1-chloropentene-2
1-hexene-3-yne	Not hexenyne-3.

2. **Writing names:** The names of radical replacing hydrogen atom in compound are carried out. For example, Chlorotoluene (chlorine replaced "H" atom of toluene).
   Elision of vowels: To avoid ambiguity vowels, whether pronounced or silent are generally retained in systematic naming. This results in using of double vowels, e,g, cyclooctane.

However it has been accepted to elide following vowel a,e and o in the following circumstances.

(i) When preceding the suffix name of a functional group, example
Propanol not propaneol
Hexamine not hexane amine.

(ii) Naming Alkenes and Alkynes on the same compound-example Pentenyne not penteneyne.

3. **Punctuation marks:** Most commonly used punctuation in naming organic compounds are hyphens, commas and enclosing brackets.

(i) ***Hyphens:***

(a) Used to connect numbers and letters serving as a locants.
For example: 2-Chloropropanone 1-Bromo-3-chlorobutane.

(b) Used to connect the prefixes like *cis, trans* (configurational prefixes) or structural prefixes (*sec, tert, neo*) with the compound name.
For example: *Cis*-2-butene, tert–butyl alcohol
The prefixes *cis, trans, iso, neo, tert etc* should be in italics.

(ii) ***Commas:*** Used to separate individual members of a series of locants.
Example: 1,1,2-Trichloro propane.

(iii) ***Enclosing brackets:*** Parenthesis ( ) and square [ ] are used as demarcation symbols when the locants are related to complete names. Example: 4-amino-N-(hydroxyl ethyl) butyramide.

Writing the structural formula from the given IUPAC name: To write the chemical strcture of a given compound from the IUPAC name, the following steps are to be adopted.

(i) ***Locate the parent alkane:*** From the name write the number of carbon atoms of the alkane in a straight chain and number them from any one of the end.

(ii) ***Locate the suffix:*** Locating suffix gives information about chain length, nature of functional group along with the positions.

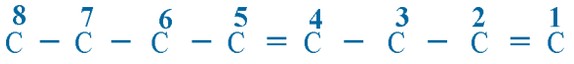
(iii) ***Locate the groups / substituents:*** As mentioned in prefix locates the groups position in the chain.

(iv) ***Add hydrogen atoms if required to satisfy:*** Four valencies of each carbon atoms to get the formula.

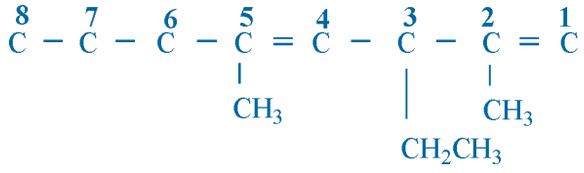
Thus, for writing the structural formulae of 3-ethyl-2,5-dimethyl-1,4-octadiene.

(i) Parent alkane is octane. Write eight carbon atoms in a straight chain and number it.

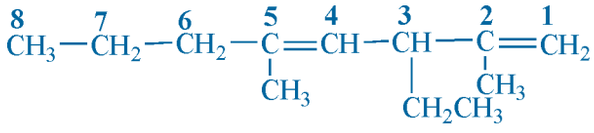
(ii) The suffix diene indicates two double bonds in 1 and 4 points.



(iii) To locate the groups mentioned in prefix we attach ethyl group on 3rd C and methyl groups to 2nd C and 5th C to get the desired compounds.



(iv) Finally to satisfy valencies hydrogen atoms are added.



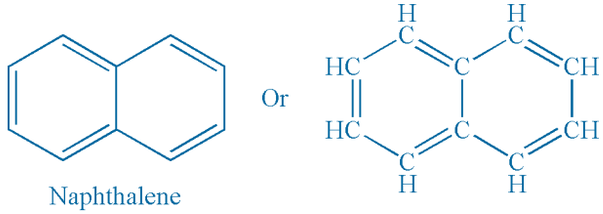
3-Ethyl-2,5-dimethyl-1,4-octadiene

25

Polynuclear Hydrocarbons

Introduction

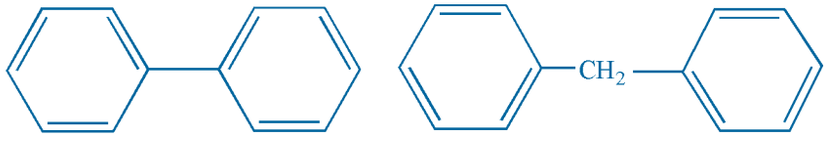
Polynuclear hydrocarbons or condensed nuclear hydrocarbons are compounds in which two or more carbon atoms are shared commonly by two or more aromatic rings. Simple examples of these type of compounds are naphthalene, anthracene, phenanthrene and their derivatives. In naphthalene two carbon atoms are shared by two benzene rings as shown below.



Naphthalene Naphthalene

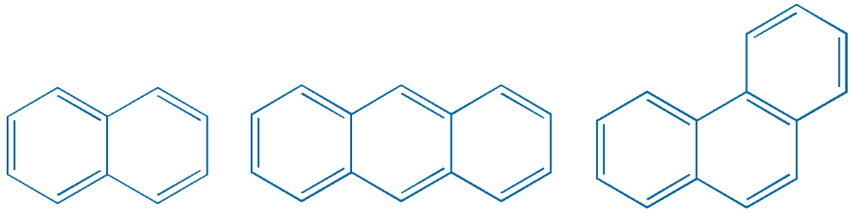
Types: Polynuclear hydrocarbons are classified into two types.

1. **Compounds in which the rings are isolated,** example: Biphenyl, diphenyl methane *etc.*



Biphenyl Diphenyl methane

2. **Compounds in which the two or more rings are fused in *o*-positions:** Naphthalene, anthracene and phenanthrene.



Naphthalene Anthracene Phenanthrene

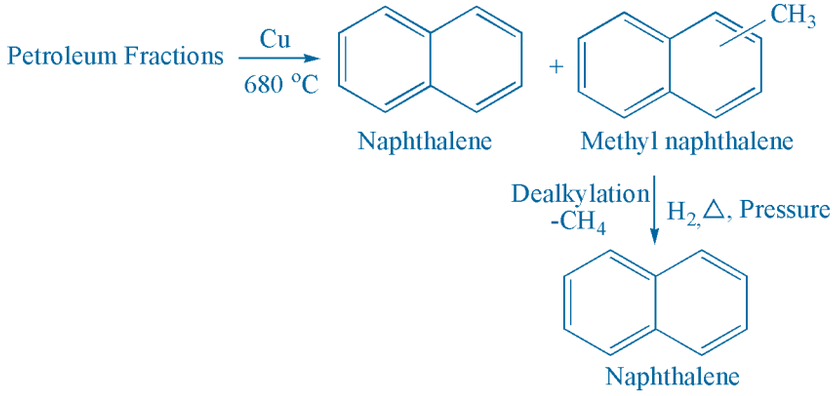
Naphthalene

Manufacture of naphthalene: Major source of naphthalene is coal tar. Coal tar contains 6-10% of naphthalene and it is present in the middle oil fraction of coal tar and obtained by distillation process. Allow the middle oil to cool, maximum amount of naphthalene is crystallized out and is collected by

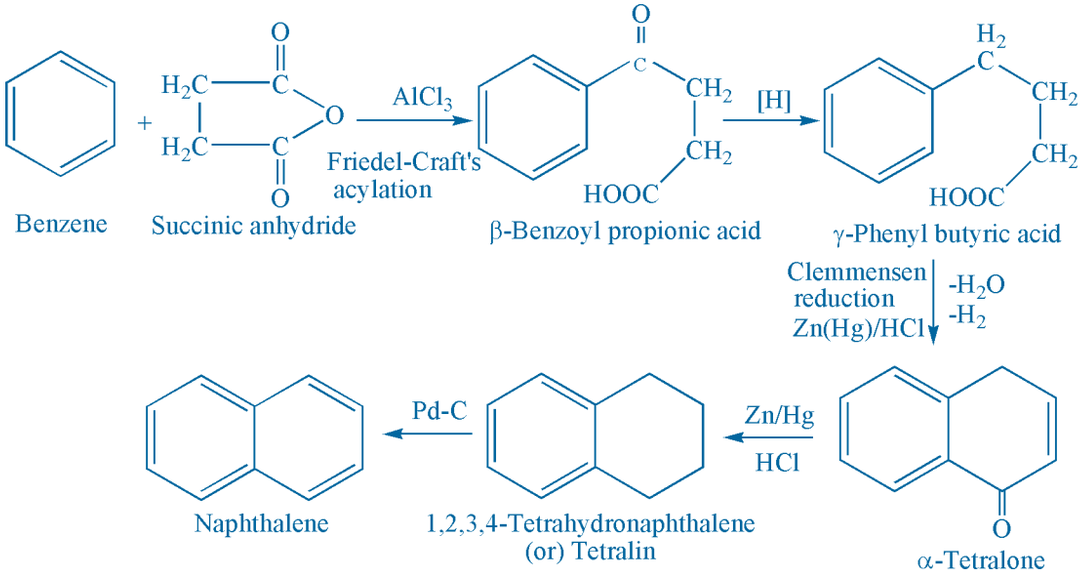
centrifugation or pressing out the oil in a hydraulic press. The crystals obtained are washed with water and with sodium hydroxide solution in a centrifuger to remove adhered oil and phenols. Then it is treated with conc. H_2SO_4 to remove the alkaline impurities, the crude naphthalene obtained is purified by sublimation and further purified by recrystallisation with petroleum ether. Nowadays the "hot processing process" is replaced by continuous washing or distillation.

Synthesis

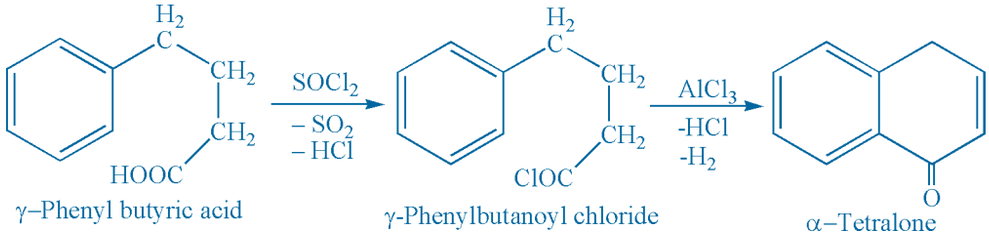
1. **From petroleum fractions:** Petroleum fractions are passed over a heated copper catalyst at 680 °C at atmospheric pressure to give naphthalene and methyl naphthalene and the later undergoes hydro dealkylation to give naphthalene.



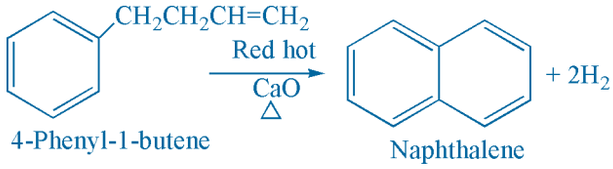
2. **Haworth synthesis:** Benzene is treated with succinic anhydride followed by reduction to yield γ-phenyl butyric acid. The later one undergoes ring closure reaction in the presence of conc. H_2SO_4 to yield α-tetralone. Reduction of α-tetralone with Zn(Hg)/HCl yields tetrahydronaphthalene (tetralin) which upon further dehydrogenation yields naphthalene by heating with selenium or palladised charcoal. The sequence of the chemical reactions are as follows.



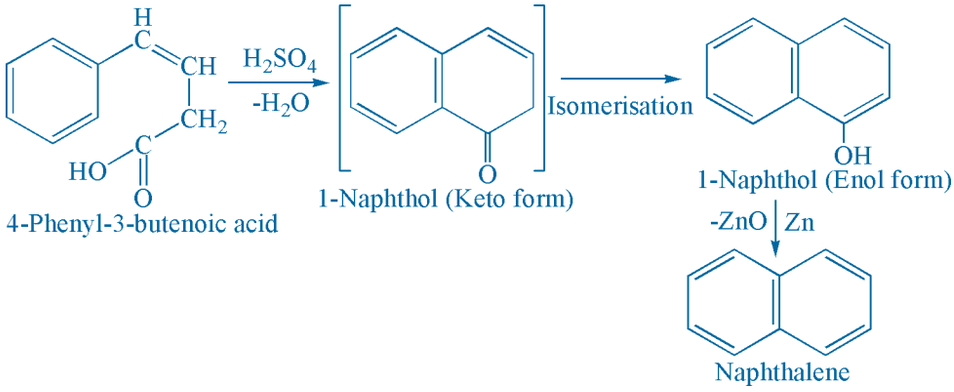
Ring closure is also effected by Friedel-Crafts reaction on acid chlorides as shown below.



3. **From 4-phenyl-1-butene:** When 4-phenyl-1-butene is passed over red-hot calcium oxide naphthalene is obtained.



4. **From 4-phenyl-3-butenoic acid:** When 4-phenyl-3-butenoic acid is warmed with conc. H_2SO_4 1-napthol is formed which upon further distillation with Zn dust yields naphthalene.



Physical Properties: It is a colorless crystalline substance with characteristic odour (moth ball odour). It is very volatile and readily sublimes on heating. It is insoluble in water but soluble in organic solvents.

Chemical Properties: Chemical properties of naphthalene resembles to that benzene. It is less aromatic than benzene and forms substitution products more readily than benzene. Like alkenes it forms addition products readily than benzene. But as soon as one of the rings is saturated or destroyed by oxidation, the second ring is stable as the benzene ring. The important characteristic reactions of naphthalene are as follows.

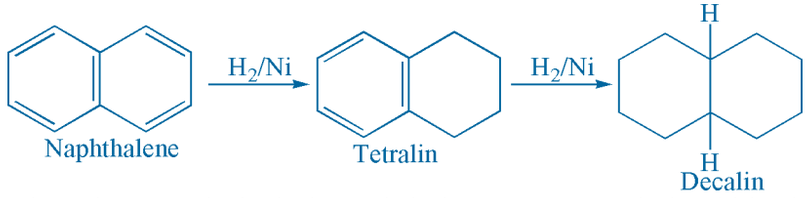
(I) Addition reactions.

(II) Electrophilic aromatic substitution reactions.

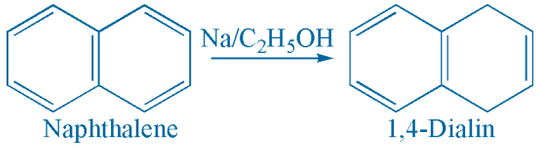
(I) Addition reactions

1. **Addition of hydrogens:** Naphthalene gives different kind of products depending upon the type of reducing agents used.

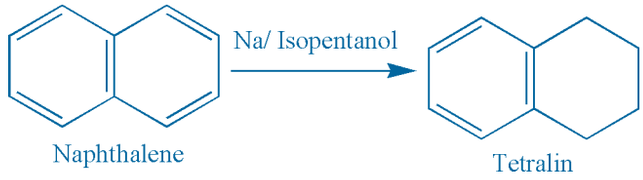
(a) With catalytic reduction using nickel yields decalin or decahydro naphthalene



(b) With sodium and alcohol, naphthalene gives 1,4-dialin (dihydronaphthalene).

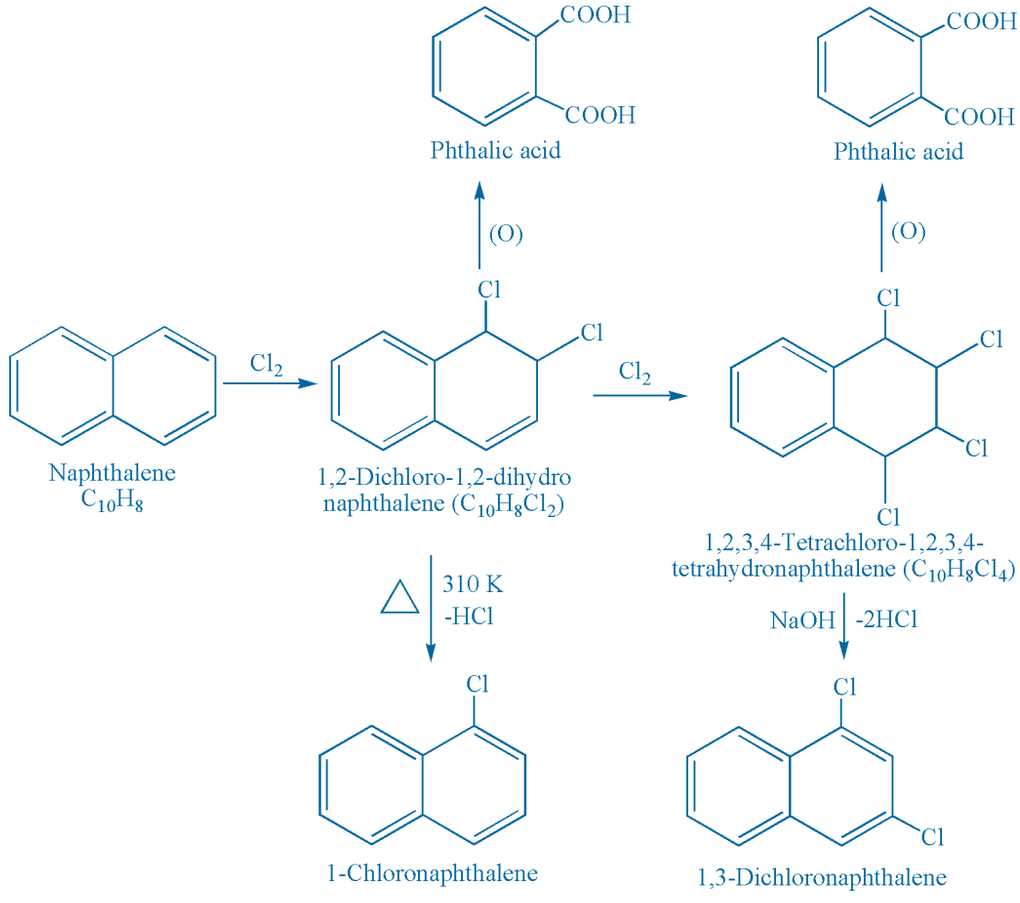


(c) With sodium and isopentanol naphthalene gives 1,2,3,4- tetrahydro naphthalene or tetralin.

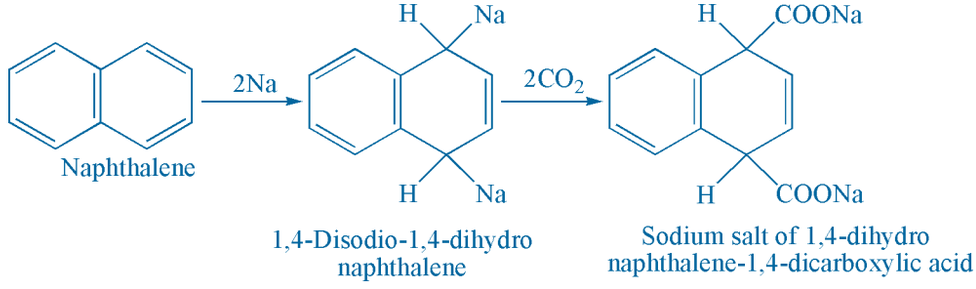


2. **Addition of chlorine:** Solid naphthalene reacts with dry chlorine to give naphthalene di and tetra chlorides. Both of them undergo oxidation to yield phthalic acid. It indicates that the halogen atoms are present in the same ring.

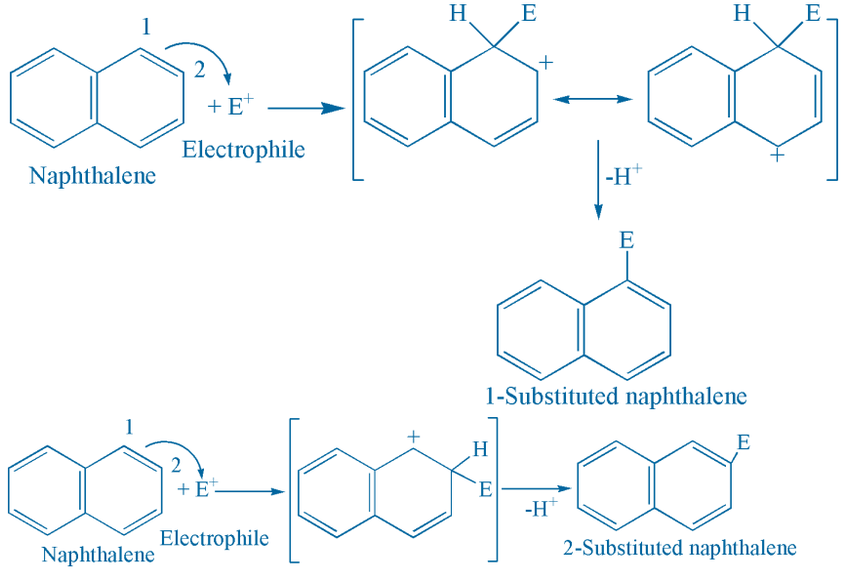
The naphthalene dichloride when heated at 310 K, loses one molecule of hydrogen chloride and gives 1-chloro naphthalene. Naphthalene tetrachloride on treatment with alkali gives dichloro naphthalene.



3. **Addition of sodium:** Naphthalene upon reaction with sodium gives 1,4-disodio naphthalene which reacts further with carbon dioxide with the formation of sodium salt 1,4-dihydro naphthalene-1,4-di carboxylic acid.

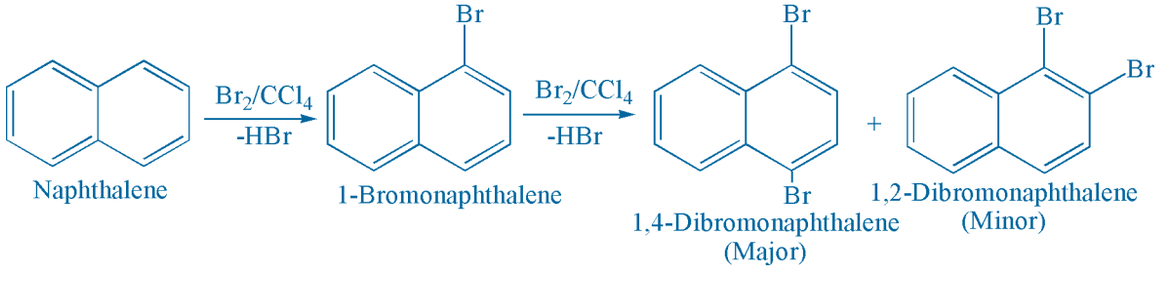


(II) Electrophilic aromatic substitution reactions: Naphthalene undergoes electrophilic aromatic substitution reactions and the major substitution occurs at C_1 (α-position) and C_2 positions.

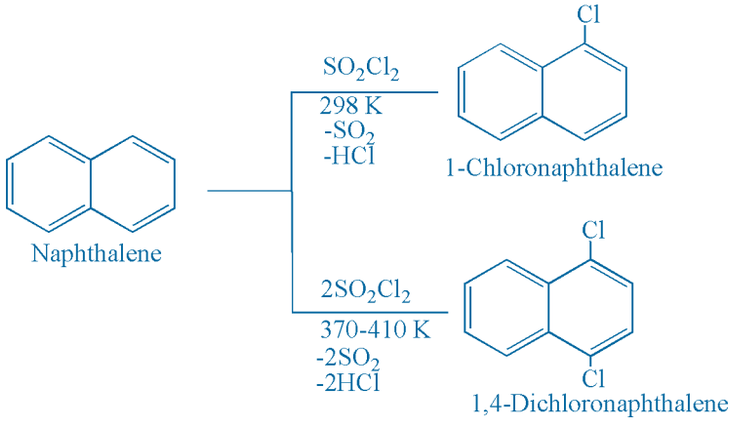


The product by C-1 attack is always predominates because the carbonation intermediate obtained by C-1 attack is more stable (due to resonance), the C-2 attack is possible only when the reaction occurs at high temperature or when bulkier solvents are used.

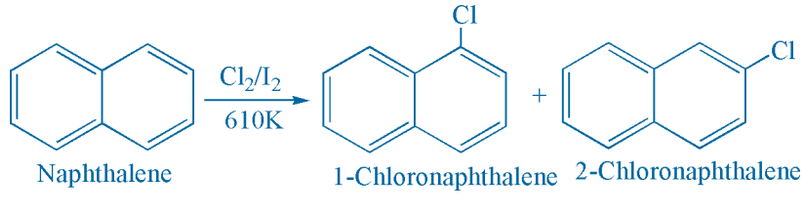
1. **Halogenation (Bromination):** Naphthalene reacts with bromine in boiling carbon tetrachloride solution to give 1-bromonapthalene. Further bromination gives mainly the 1,4-dibromo naphthalene with small amount of 1,2-dibromo naphthalene.



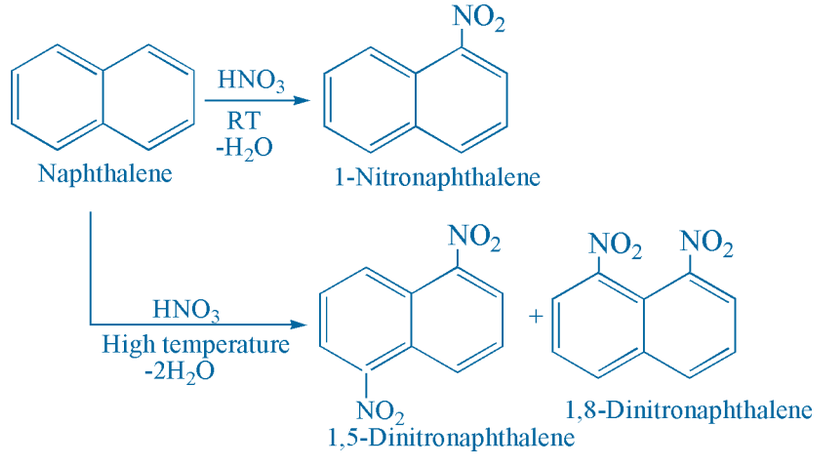
Chlorination: Naphthalene reacts with sulphuryl chloride in the presence of aluminium chloride. Naphthalene reacts with one equivalent of sulphuryl chloride at 298 K to give 1-chloro naphthalene and with two equivalents of sulphuryl chloride at 370-410 K to gives 1,4-dichloronaphthalene.



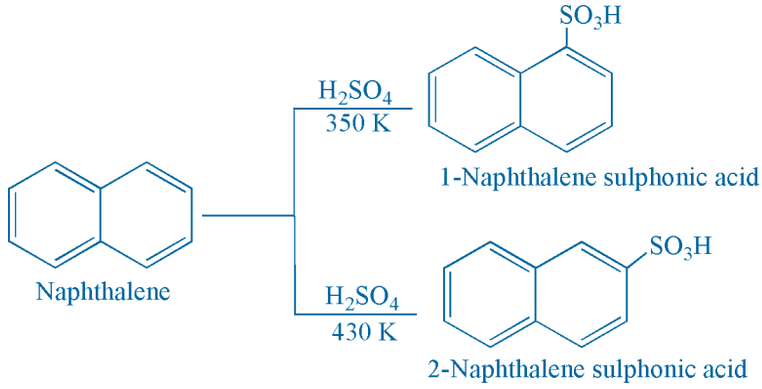
Naphthalene reacts with chlorine in the presence of iodine above 610 K and gives a mixture of 1 and 2-chloro naphthalene.



2. **Nitration:** Naphthalene reacts with nitric acid at room temperature to yield 1-nitro naphthalene and at high temperature yield 1,5 & 1,8-dinitro naphthalene.

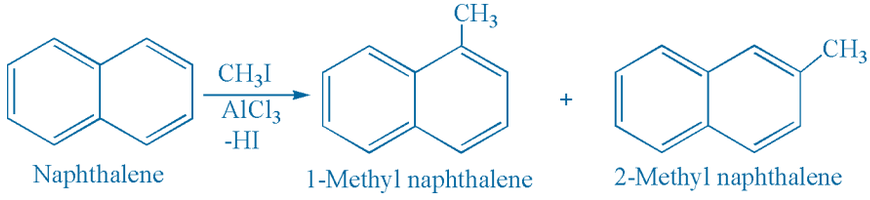


3. **Sulphonation:** Naphthalene reacts with conc. H_2SO_4 at 350 K and yields 1-naphthalene sulphonic acid, but at 430 K it gives 2-naphthalene sulphonic acid.

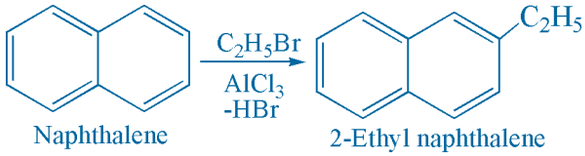


4. **Fridel-Craft's reaction:** Carry out this reaction at low temperature in the presence of anhydrous aluminium chloride. Because at high temperature, one of the naphthalene ring opened.

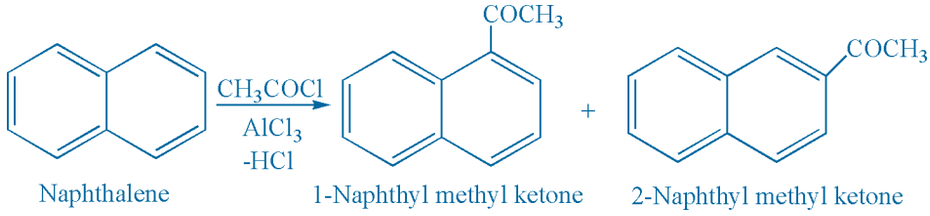
   (a) With methyl iodide: Naphthalene reacts with methyl iodide in the presence of anhydrous $AlCl_3$ and gives 1 & 2-methyl naphthalene.



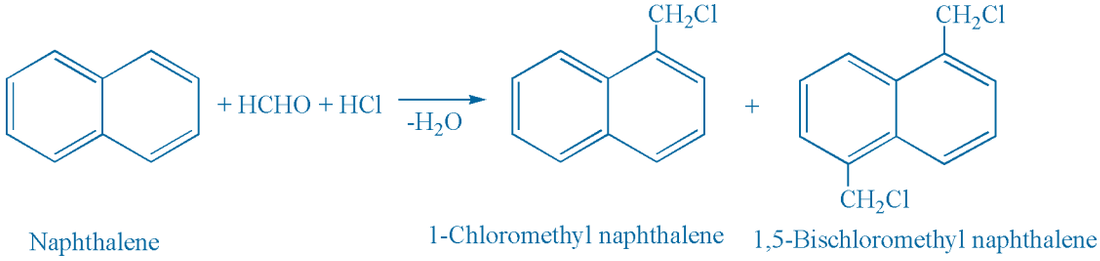
But naphthalene reacts with ethyl bromide to yield 2-ethyl naphthalene.



(b) With acetyl chloride: Naphthalene reacts with acetyl chloride and $AlCl_3$ to yield a mixture of 1-naphthyl methyl ketone & 2-napthyl methyl ketone. The composition of mixture obtained depends upon the nature of the solvent and the temperature used. For example, in the presence of CS_2 at 260 K, the 1 and 2 - derivatives are obtained in 3:1 ratio while in the presence of nitrobenzene at 298 K the product obtained is in 1:9 ratios.



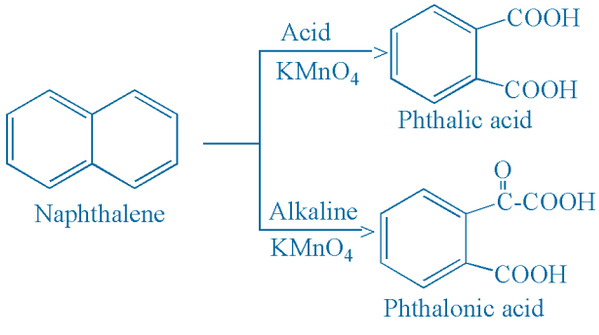
5. Chloro methylation: Naphthalene reacts with formaldehyde/HCl and glacial acetic acid, gives 1-chloro methyl naphthalene with a small amount of 1,5-bis chloromethyl naphthalene.



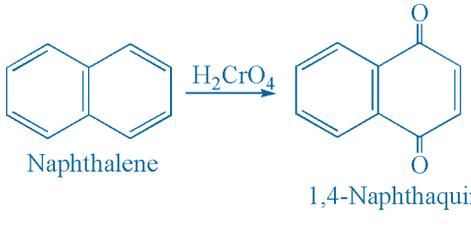
6. Oxidation: Naphthalene gives different kind of products on oxidation. The products formed depend upon the nature of the oxidizing agents used.

The various kind of oxidation reactions are as follows.

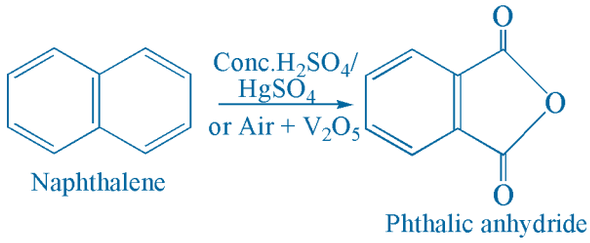
(i) With potassium permanganate: Naphthalene reacts with acidic $KMnO_4$ and alkaline $KMnO_4$ to give phthalic acid and phthalonic acid respectively.



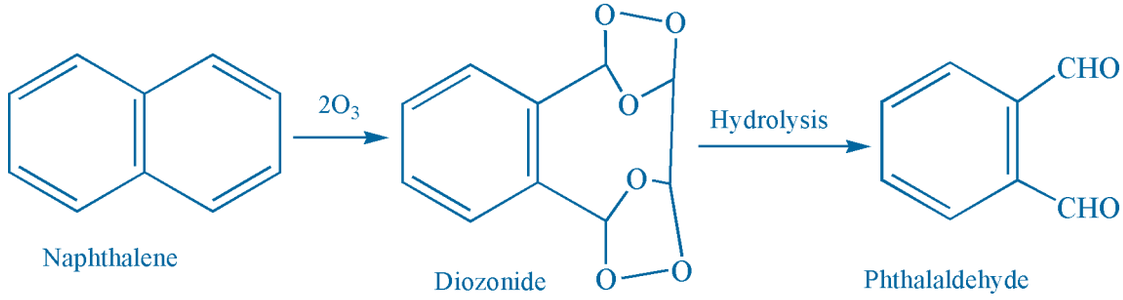
(ii) With chromic acid: Naphthalene when oxidised with chromic acid yields 1,4-naphthaquinone.



(iii) Naphthalene reacts with conc. H_2SO_4 and mercuric sulphate or air in the presence of vanadium pentoxide and yields phthalic anhydride.



(iv) With ozone: Naphthalene is oxidized with ozone to give diozonide which upon hydrolysis gives phthalaldehyde.



Uses:

1. It is used as an insecticide and for preventing moths in clothes.
2. Large amount of naphthalene is used in industry for the manufacture of various dye stuffs such as indigo, azo dye and eosin.
3. It is also used for manufacturing of phthalic anhydride, phthalic acid and phthalimide *etc.*
4. Local gas is carbureting with naphthalene.

Medicinally useful compounds containing naphthalene

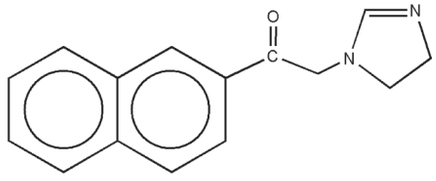
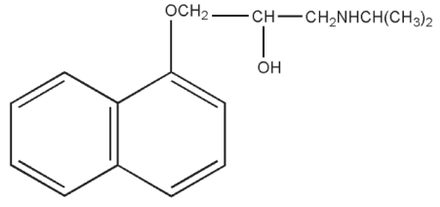
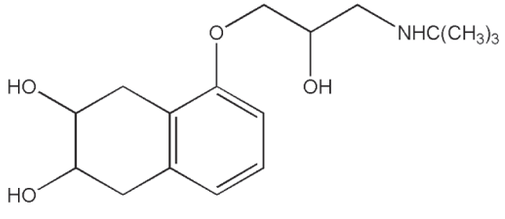
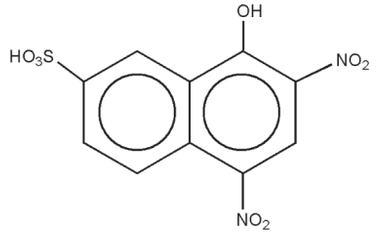
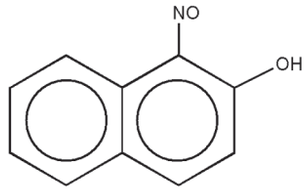
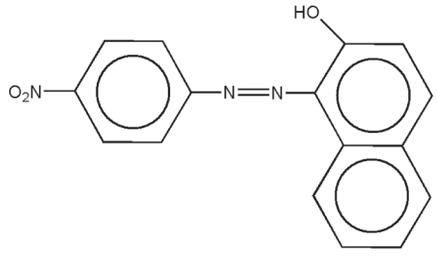
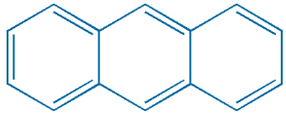
Nafimidone  **Use:** It is used as an anticonvulsant.	**Propranolol**  **Use:** It is used in the treatment of tachycardia.
Nadolol  **Use:** It is used as an antihypertensive drug.	**Naphthol yellow S**  **Use:** It is used as a dye.

Table *Contd...*

Mordant green 4	Para red azo dye
	
Use: It is used as a dye.	**Use:** It is used as a dye.

Anthracene

Anthracene is another example of fused aromatic hydrocarbons in which three benzene rings fused together in the *o*-positions.



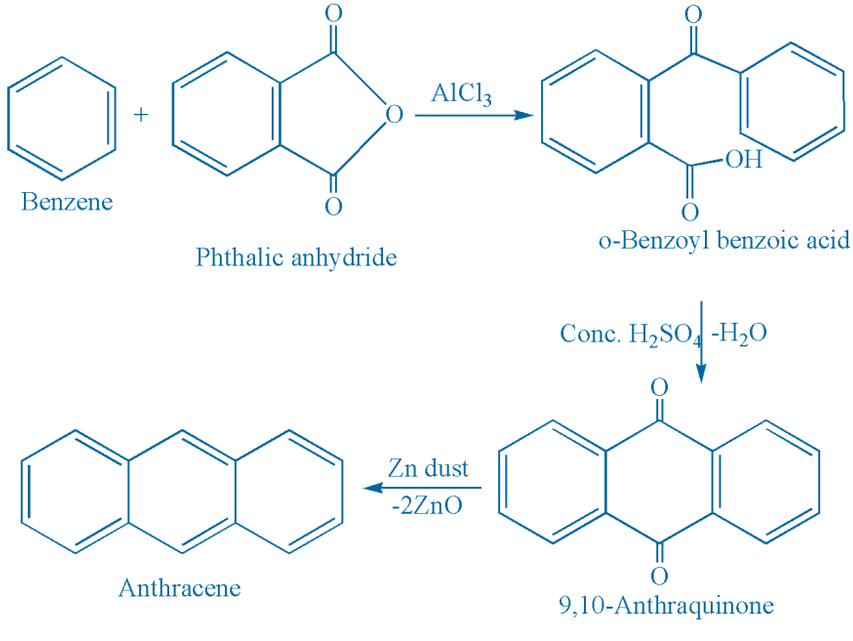
Anthracene is present in coal tar less than 1%. The name derives from the Greek word anthraz (means coal). High boiling point fraction of coal tar also contains anthracene, hence called as anthracene oil.

Preparation of anthracene: Coal tar is a chief source of anthracene and it contains 0.25-0.45% of anthracene. It is present in anthracene oil or green oil along with phenanthrene, carbazole and other substances.

Anthracene oil is allowed to stand in shallow tanks where by a viscous mass separates out and the crude anthracene (20%) is removed by filtration. During this, the anthracene content increases up to 35% and some amount of oil is removed by centrifuge when 50% anthracene is obtained. The resulting product is powdered and washed with solvent naphtha which dissolves out phenanthrene and then treated with pyridine which removes carbazole. Anthracene is finally crystallized out from benzene.

Synthesis

1. **Haworth synthesis:** Benzene reacts with phthalic anhydride in the presence of $AlCl_3$ to yield o-benzoyl benzoic acid, which upon reaction with conc. H_2SO_4 to yield 9,10-anthraquinone. The later obtained is distilled with Zn, and yields anthracene.

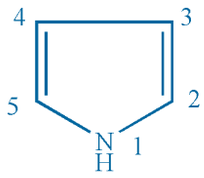


29

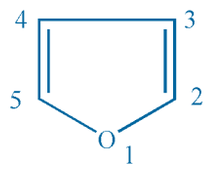
Heterocyclic Compounds (Part 1)

Introduction to Heterocyclic compounds

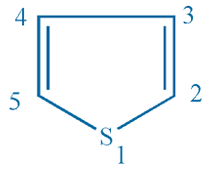
Heterocyclic compounds are cyclic compounds in which the ring carbon atoms are displaced or substituted with one or more polyvalent atoms. The major substituted polyvalent atoms are nitrogen, oxygen and sulphur as shown in the following examples.



Pyrrole



Furan

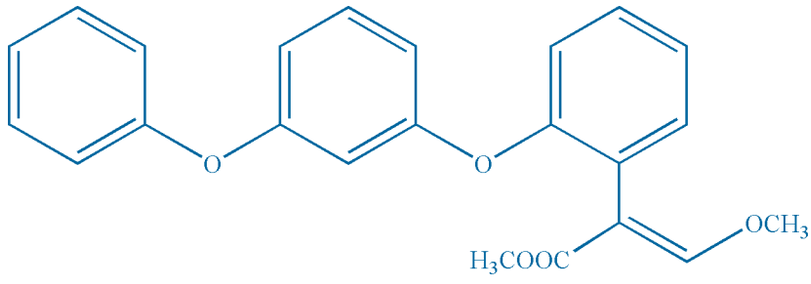


Thiophene

Heterocycles possess wide range of applications in day to day life, such as drugs, veterinary products and agrochemicals. They are also used as antioxidants, dyestuffs, pigments and additives *etc*.

Why heterocyclic compounds are very important in organic chemistry?

1. "Easy manipulation of ring system is possible to attain a required modification leads to the formation of different structural variations with different properties. This phenomenon is an useful strategy for developing new drugs. For example, consider the following compound I, which acts as a fungicide and it is highly lipophilic in nature; the water solubility of the compound is increased by the replacement of the benzene ring with suitable heterocycles.



(I)

2. Another important fact is we can easily accommodate any functional groups into the heterocycles framework as a substituent or as a part of the ring system itself. It makes heterocyclic chemistry as a very peculiar part in organic chemistry.
3. Heterocycles or heterocyclic compounds are widely distributed in nature as important fundamental units of living systems as shown below with examples.
   (i) Nucleic acid contains pyrimidine and purine rings, which are responsible for cell replication.

(ii) Chlorophyll and heme contains porphyrin ring system which is needed for photosynthesis and for respiration (oxygen transport) in higher plants and animals respectively.

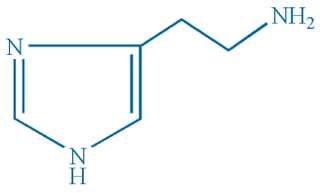
(iii) Vitamins: Thiamine (vitamin B_1), riboflavin (vitamin B_2), pyridoxol (vitamin B_6), ascorbic acid (vitamin C) - All are heterocyclic compounds.

(iv) Amino acids: Histidine, prolines, and tryptophan are possesing heterocyclic rings.

Pharmaceutical applications of heterocyclic compounds: Many of the drugs are heterocyclic in nature and possess heterocyclic ring skeleton. They are not extracted from the nature due to the difficulties in extraction and purification process. Hence they are manufactured or synthesized in the laboratories.

The origin of organic chemistry is based on the natural products and many of the drug candidates are developed subsequently. Some of the examples are described below.

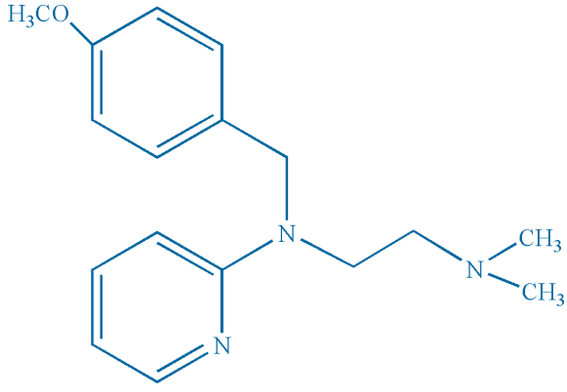
Development of Histamines and Antihistamines



(1)

Histamine

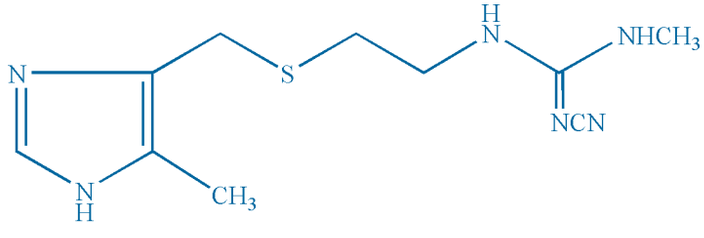
Histamine (1), a monosubstituted imidazole ring system released in our body from the amino acid histidine by decarboxylation. The main pharmacological actions of histamine includes contraction of smooth muscle, fall in BP (hypotension), producing allergic reactions and regulation of gastric acid secretion. For antagonising the action of histamine several kind of drugs are synthesized from 1940. One of the important drug is pyrilamine, a pyridine derivative (2).



Pyrilamine (2)

Pyrilamine antagonizes or inhibits the several actions of histamine but it does not block the gastric acid secretion.

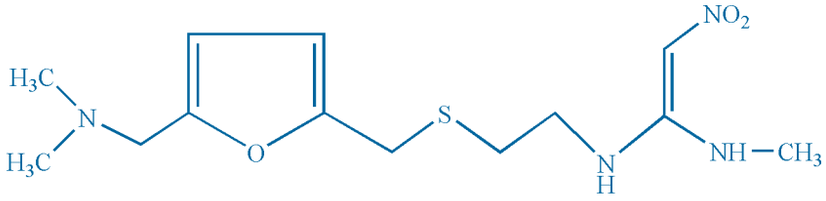
In 1976, the lacunae of pyrilamine is encountered by chemists with modification of the structure of histamine and discovered an active drug known as cimetidine (3), used for the treatment of peptic ulcer.



Cimetidine (3)

Cimetidine is one of the major leading drug in 1970s and 1980s being the first non-surgical treatment of peptic ulcer. Further development of cimetidine analogues are promoted by changing the heteroyclic ring in the cimetidine molecule.

Ranitidine, pyrrole ring of the cimetidine is replaced by furan, is also a successful drug for the treatment of peptic ulcer.

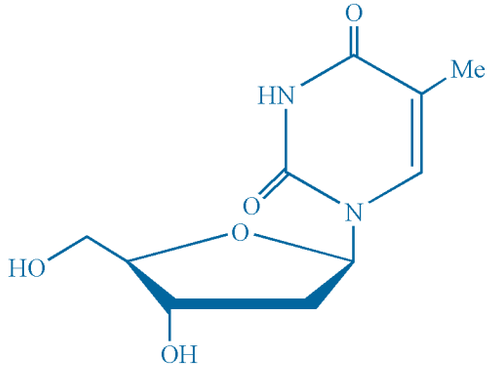


Ranitidine

Development of Nucleoside Analogues

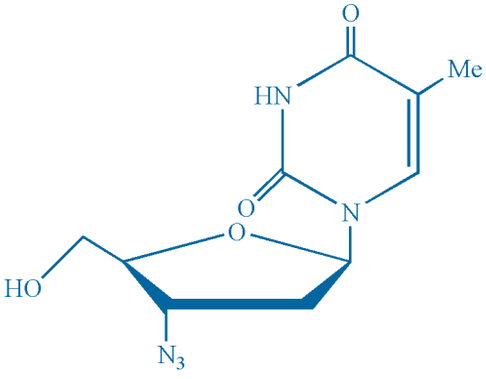
In the search for drugs to combat cancer and virus modification in the structure of DNA is the best approach by synthesizing the nucleosides.

These analogues consists of pyrimidine and purine nucleus which is attached to a sugar moiety as shown in the following examples.



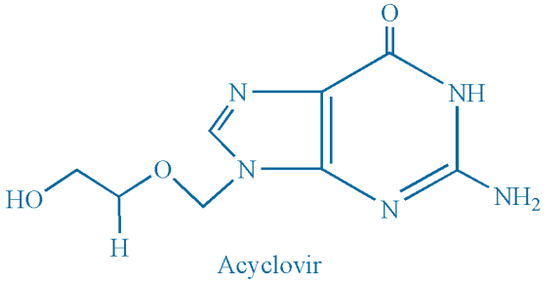
2-Deoxythymidine

Various nucleic acid analogues are developed by the structural modifications of heterocycles or sugar or both and yielded the important drugs as mentioned below.



Zidovudine

(Used in the treatment of AIDS,
Close analogue of 2'-deoxythymidine)

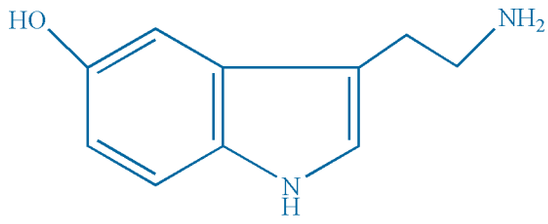


Acyclovir
(Used for the treatment of herbs virus infections, Analogue of 2'-deoxyguanosine)

Development of Alkaloidal Drugs

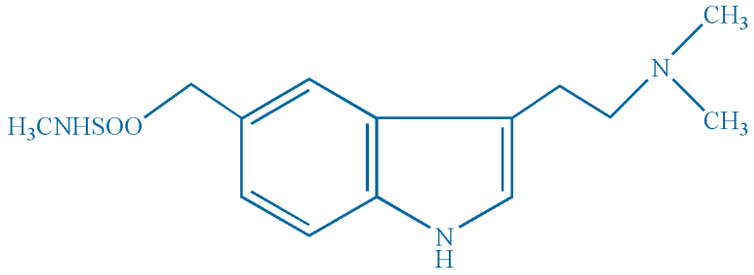
Development of Serotonin Analogues

Serotonin: Vasoconstrictor drug obtained from natural source is widely distributed in nature but present only in very low concentration. It was first extracted from natural source in 1948.



Serotonin

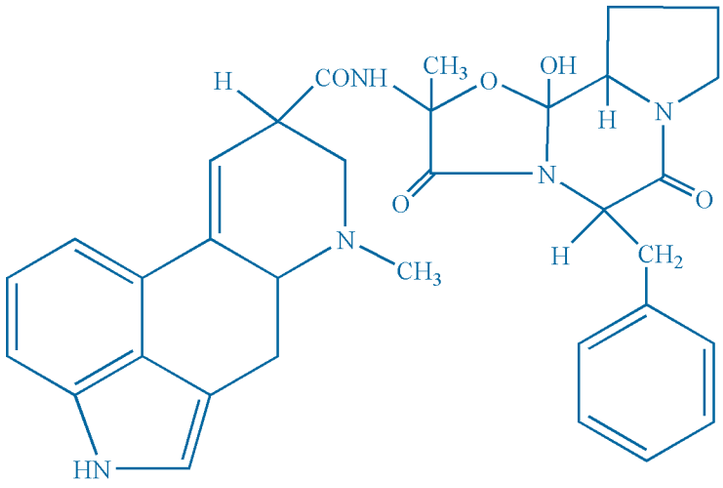
Synthesis of this drug was done in laboratories after few years and it is used for investigating the mechanism of action. The main pharmacological actions of serotonin includes constriction of brain arteries, behavourial changes in the body *etc,*. But the main drawback of serotonin is that it is too rapidly metabolised in the brain. This was overcome by designing the serotonin analogues and the simple indole derivative of serotonin such as sumatriptan was developed by researchers which acts as a selective agonist at serotonin receptor sites in the brain and used as a drug of choice for the treatment of migraine.



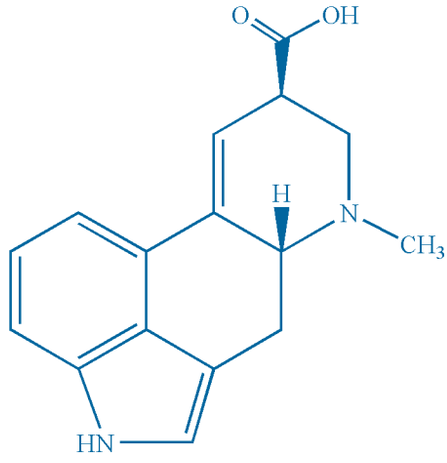
Sumatriptan
(Indole derivative of serotonin used for migraine)

Ergot alkaloids:

Ergotamine: An indole alkaloid possesing aminoethyl side chain at 3rd position, is used in migraine at low doses. But the drug is highly toxic and not in use. But its synthetic analogue lysergic acid diethylamide (LCD) is discovered and it is now notorious as a hallucinogen.



Ergotamine



Lysergic acid

Nomenclature of Heterocyclic Compounds

Heterocyclic compounds are named by using trivial names as well as systematic names. Trivial name does not provide the detailed information about the structure but still it is used (In recent years the IUPAC has made efforts to systematize the nomenclature of heterocyclic compounds).

According to the IUPAC system, following guidelines are used for naming the heterocycles.

1. The monocyclic compounds are named by a prefix which is derived from the nature of the hetero atom present in it (Eliding "a" where necessary). Some of the rings and their prefixes are indicated in the following Table 29.1.

Table 29.1 Prefix for Hetero Atoms.

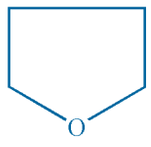
Nature of hetero atom	Symbol	Respective prefix
Oxygen	O	Oxa
Nitrogen	N	Aza
Sulphur	S	Thia
Phosphorous	P	Phospha
Selenium	Se	Selena
Silicon	Si	Sila
Germanium	Ge	Germa

2. If the same hetero atom is present more than one time, the prefixes di, tri *etc* are used.
   For example: dioxa, triaza *etc*.
3. If different heteroatoms are present in the ring, the naming starts from the atom which is high group in periodic table and as low in atomic number in that group. Hence the order of naming is as follows O, S, N, P, Si *etc*.
4. When the size of the monocyclic ring is from 3 to 10, they are indicated with suffixes which are mentioned in the Table 29.2.

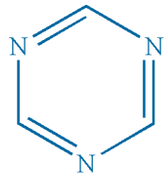
Table 29.2 Common name endings for heterocycles.

Nature of the ring size	Suffixes for completely unsaturated compounds		Suffixes for completely saturated compounds	
	With N	Without N	With N	Without N
3	-irine	-irene	-iridine	-irane
4	-ete	-ete	-etidine	-etan
5	-ole	-ole	-olidine	-olane
6	-ine	-in	-	-ane
7	-epine	-epin	-	-epane
8	-ocine	-	-ocin	-ocane
9	-onine	-onin	-	-onan
10	-ecine	-ecin	-	-ecan

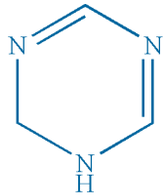
5. The nature of hydrogenation is indicated by the suffixes as mentioned in the above table or prefixes dihydro, tetrahydro *etc*. or by prefixing the parent unsaturated compound with the symbol H preceded by a number indicating the position of saturation. For example:



Tetrahydrofuran

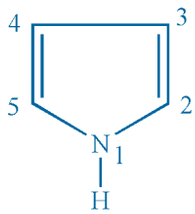


1,3,5-Triazine

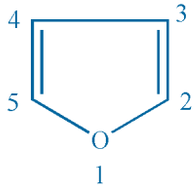


1,2-Dihydro-1,3,5-triazine

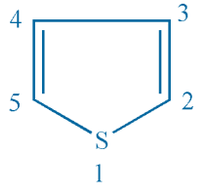
6. In monocyclic ring system with one hetero atom, numbering start from that atom only.



Pyrrole



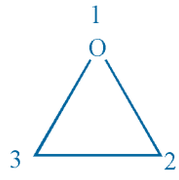
Furan



Thiophene

According to the above system, some of the heterocycles and their nomenclature are mentioned below.

Example 1:



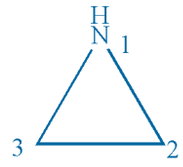
Ox**irane**

[Three membered ring without N and full saturation]

Ox**irene**

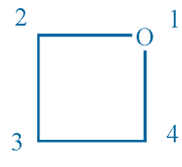
[Three membered ring without N and unsaturation]

Example 2:



Aziridine

[Three membered ring with N and saturation]

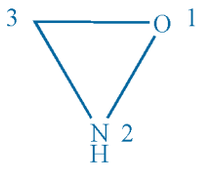


Oxetan

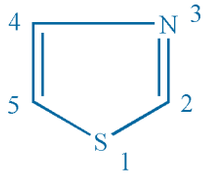
[Four membered ring with O and saturation]

Example 3:

If two or more different atoms are present in the ring, naming is given by combining the prefixes of the heteroatoms.

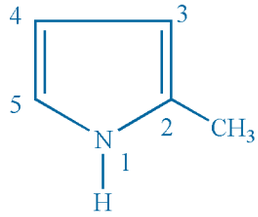


Oxa aziridine

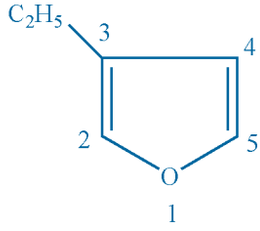


Thiazole

Nature of the substituents: In substituted heterocycles, the numbering starts from the hetero atom (assigned position 1) and the substituents are numbered with a lowest possible numbers. The name of substituents should be mentioned in alphabetical order.

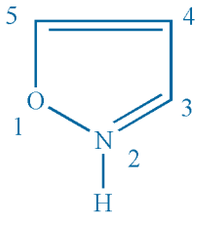


2-Methyl pyrrole



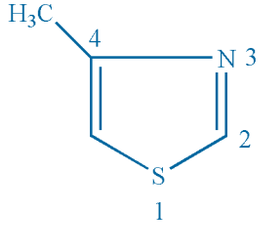
3-Ethyl furan

If the heterocycles contain more than one hetero atom, the order of preference is O, S, N. The ring is numbered from the atom of preference and preceeded in such a way so as to give the smallest possible number to the other hetero atoms in the ring. In this case, the substituents numbering need not be bothered.



[The preference of number starts from O and the next heteroatom attains lowest possible number]

Isoxazole

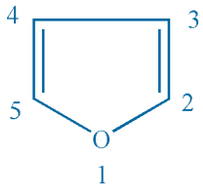


[The preference of numbering of heteroatom starts from S and the next heteroatom attains lowest possible number, no preference for subtituents]

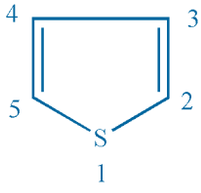
4-Methyl thiazole

7. Apart from the systematic method, many number of heterocycles are also named by common names or non-systematic names which are widely used. Few examples are shown below.

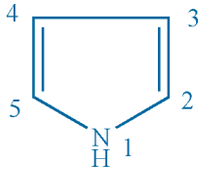
Five membered rings:



Furan

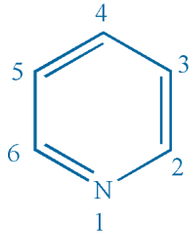


Thiophene

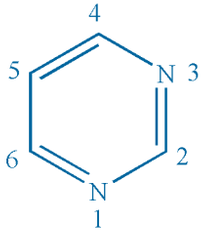


Pyrrole

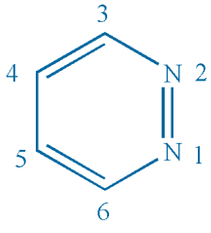
Six membered rings:



Pyridine

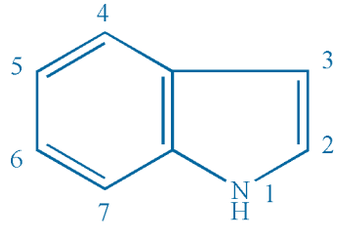


Pyrimidine

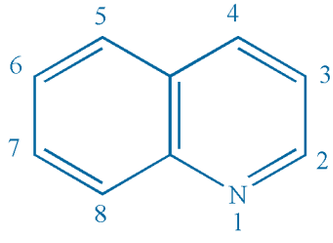


Pyridazine

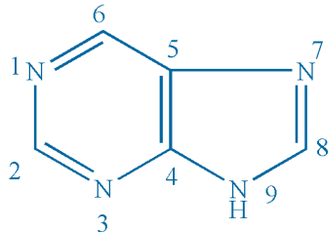
Condensed heterocycles:



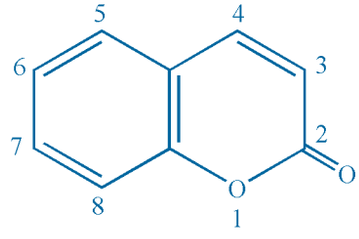
Indole



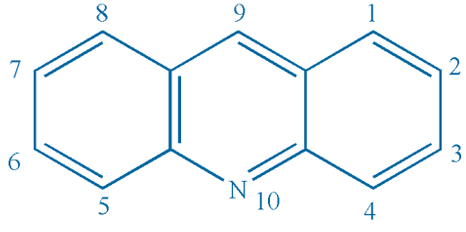
Quinoline



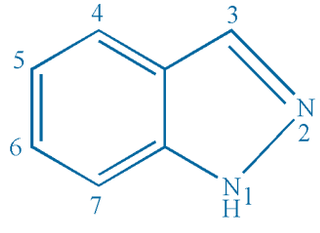
Purine



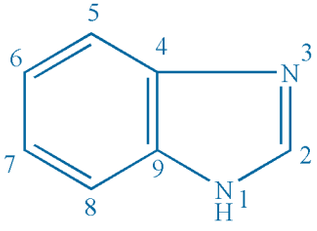
Coumarin



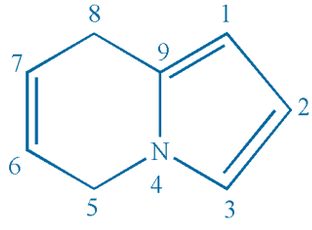
Acridine



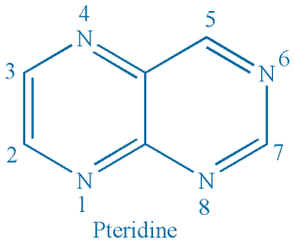
Indazole



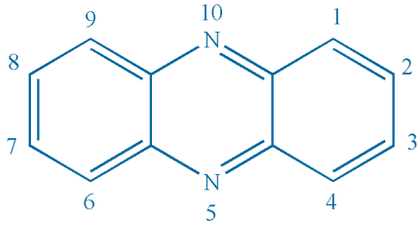
Benzimidazole



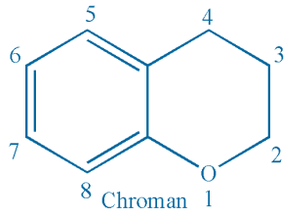
Indolizine



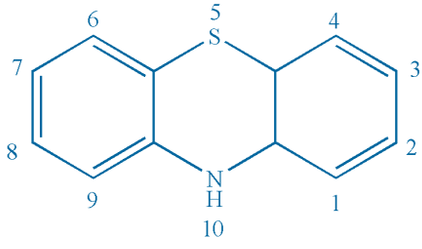
Pteridine



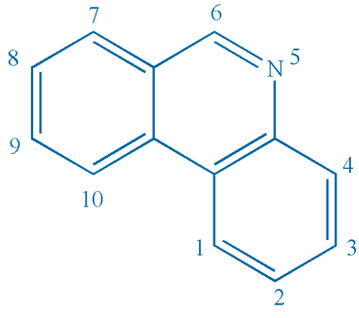
Phenazine



Chroman



Phenothiazine



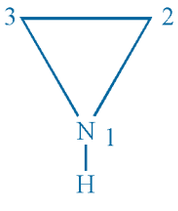
Phenanthridine

Classification of Heterocyclic Compounds

I. Three membered heterocyclic compounds with hetero atom.

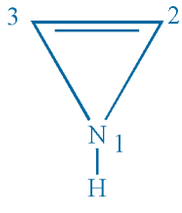
(a) With nitrogen

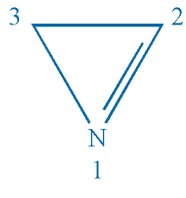
Saturated Compound



Aziridine

Unsaturated Compound

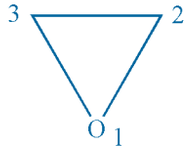




Azirine

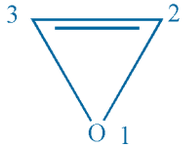
(b) With oxygen

Saturated Compound



Oxirane

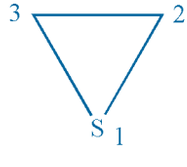
Unsaturated Compound



Oxirene

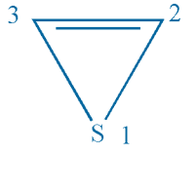
(c) With sulphur

Saturated Compound



Thiirane

Unsaturated Compound

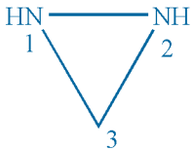


Thiirene

II. Three membered heterocyclic compounds with two hetero atoms.

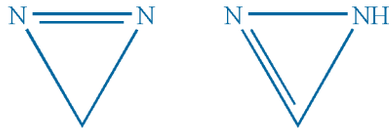
(a) With two nitrogen atoms

Saturated compound



Diaziridine

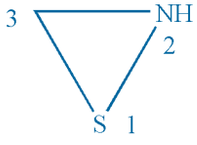
Unsaturated compounds



Diazirine

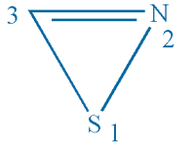
(b) With one nitrogen and one sulphur atoms:

Saturated compound



Thiaziridine

Unsaturated compound



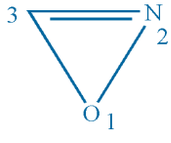
Thiazirene

(c) With one nitrogen and one oxygen atoms:

Saturated compound

Oxaziridine

Unsaturated compound

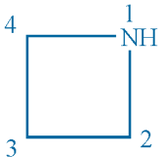


Oxaziren
e

III. Four membered heterocyclic compounds with one hetero atom.

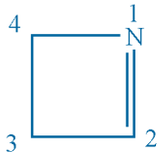
(a) With nitrogen

Saturated Compound

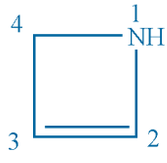


Azetidine

Partially Unsaturated Compounds

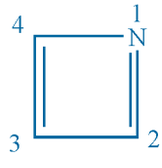


1-Azetine



2-Azetine

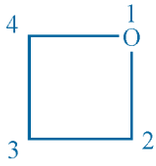
Completely Unsaturated Compound



Azete
(Antiaromatic)

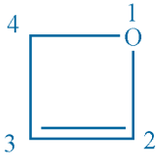
(b) With oxygen atom

Saturated Compound



Oxetane

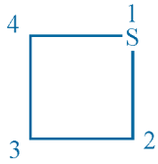
Unsaturated Compound



2-Oxetene

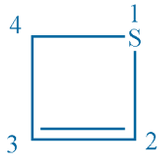
(c) With sulphur atom

Saturated Compound



Thietane

Unsaturated Compound

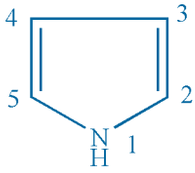


Thietene or Thiete

IV. Five membered heterocyclic compounds with one heteroatom.

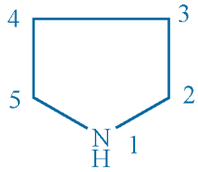
(a) With nitrogen

Unsaturated Compound



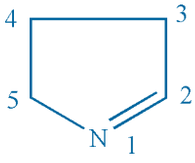
Pyrrole

Saturated Compound

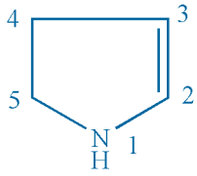


Pyrrolidine

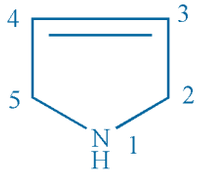
Partially Saturated Compounds



Δ^1-Pyrroline



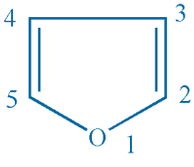
Δ^2-Pyrroline



Δ^3-Pyrroline

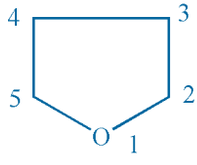
(b) With oxygen atom

Unsaturated Compound



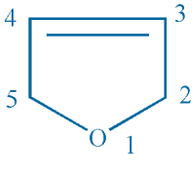
Furan

Saturated Compound

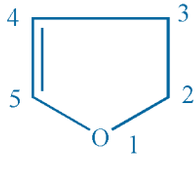


Tetrahydro furan

Partially Saturated Compounds



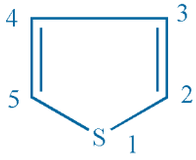
2,5-Dihydrofuran



2,3-Dihydrofuran

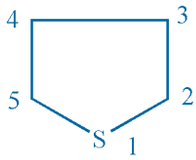
(c) With sulphur atom

Unsaturated Compound



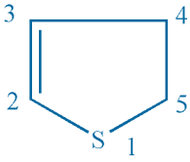
Thiophene

Fully Saturated Compound

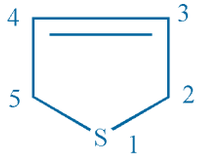


Tetrahydro thiophene (Thiolene)

Partially Saturated Compound



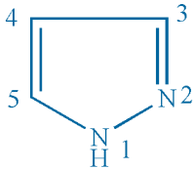
2-Thiolene
(2,3-Dihydrothiophene)



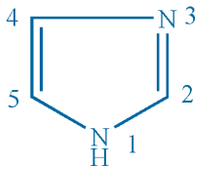
3-Thiolene
(3,4-Dihydrothiophene)

V. Five membered heterocyclic compounds with two hetero atoms.

(a) With two nitrogen atoms

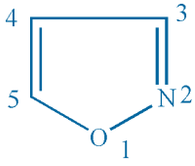


Pyrazole

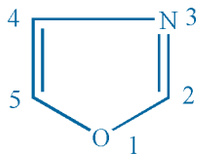


Imidazole

(b) With one nitrogen and one oxygen atom

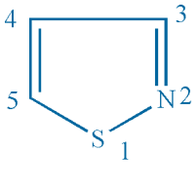


Isooxazole

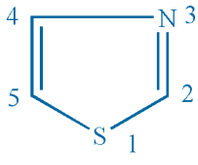


Oxazole

(c) With one nitrogen and one sulphur atom

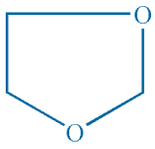


Isothiazole



Thiazole

(d) With two oxygen atoms

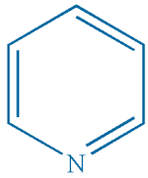


Dioxolane

VI. Six membered heterocyclic compounds with one hetero atom.

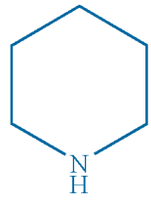
(a) With nitrogen atom

Unsaturated Compound



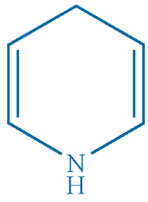
Pyridine

Fully Saturated Compound

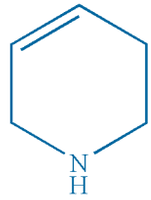


Piperidine

Partially Saturated Compounds

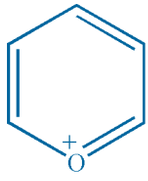


Dihydropyridine

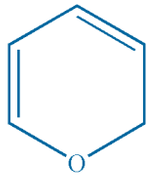


Tetrahydropyridine

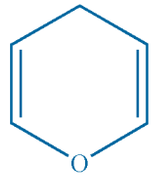
(b) With oxygen



Pyrylium salt



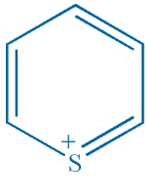
α-Pyrrones



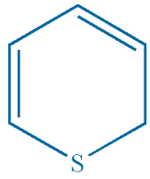
γ-Pyrrones

(Unstable and less aromatic)

(c) With sulphur



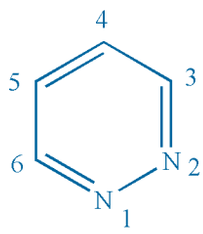
Thiopyrilium salt



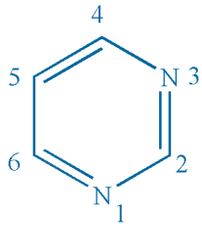
Thiopyran

VII. Six membered heterocyclic compounds with two hetero atoms.

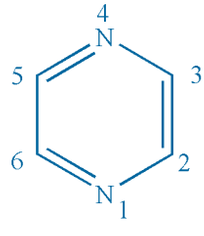
(a) With two nitrogen atoms



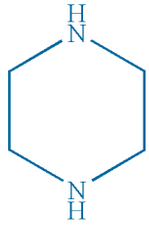
Pyridazine



Pyrimidine

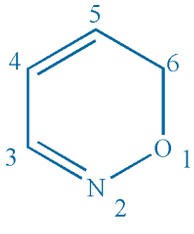


Pyrazine

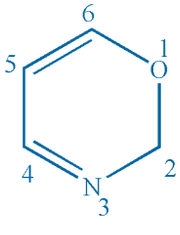


Piperazine

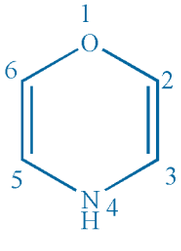
(b) With oxygen and nitrogen atoms



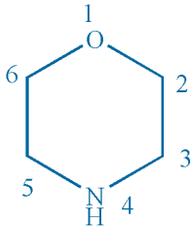
1,2-Oxazine



1,3-Oxazine

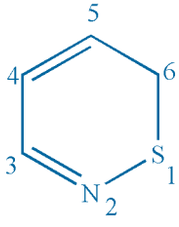


1,4-Oxazine

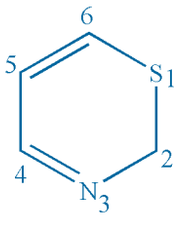


Morpholine

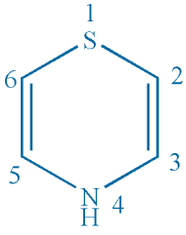
(c) With nitrogen and sulphur atoms



1,2-Thiazine

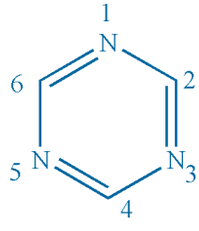


1,3-Thiazine



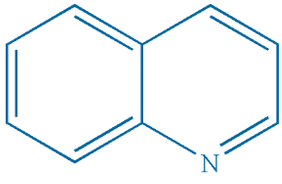
1,4-Thiazine

(d) With three nitrogen atoms

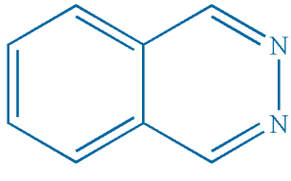


1,3,5-Triazine

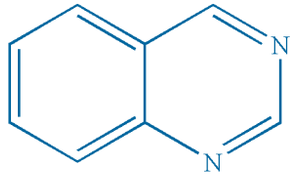
Fused rings



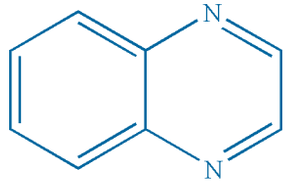
Quinoline



Pthalazine

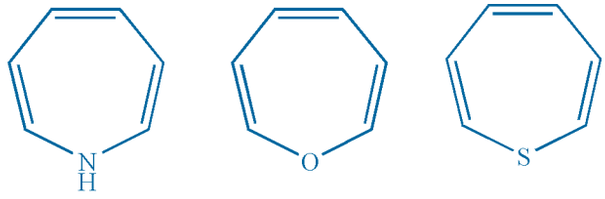


Quinazoline



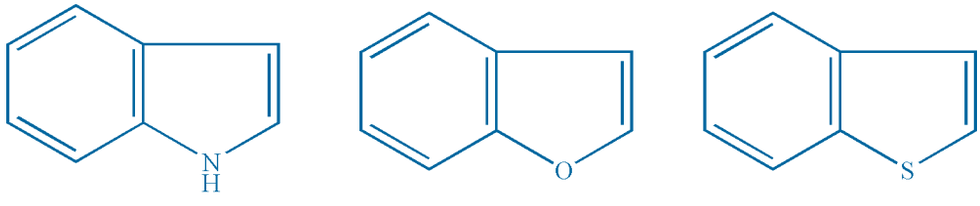
Quinoxaline

VIII. Seven membered heterocyclic compounds.

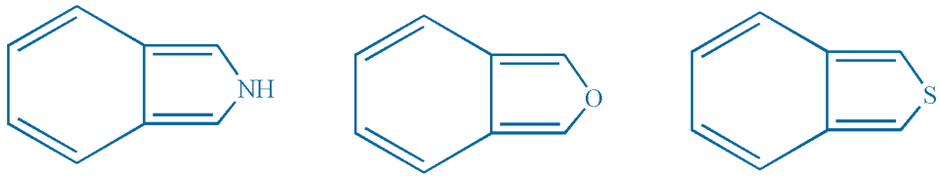


Azepine Oxepine Thiepine

IX. Bicyclic ring systems from pyrrole, furan and thiophene (fused five membered ring system).

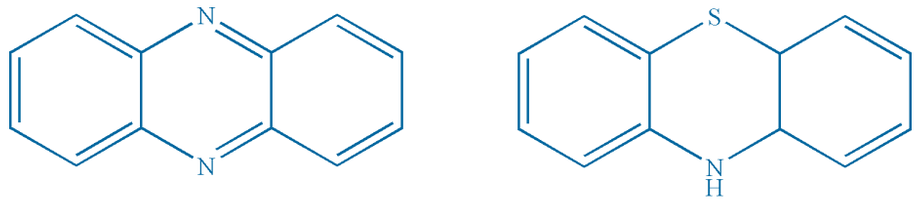


Indole Benzofuran Benzothiophene

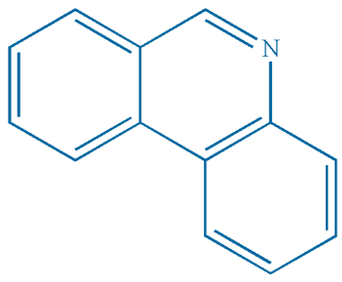


Isoindole Isobenzofuran Isobenzothiophene

X. Tricyclic heterocyclic compounds.

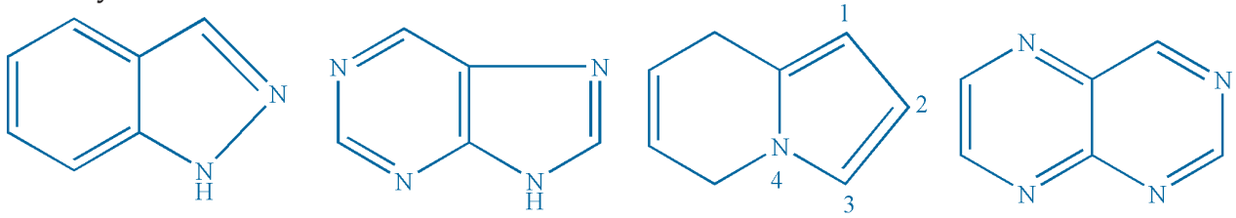


Phenazine Phenothiazine



Phenanthridine

Heterocycles with Trivial names.



Indazole Purine Indolizine Pteridine

Pharmaceutical Organic Chemistry

For B.Pharm. 2nd, 3rd and 4th Semesters as per PCI Revised Syllabus

Pharmaceutical Organic Chemistry is a much awaited great work in the field of Chemistry and Pharmacy. Targeted mainly to B. Pharmacy students, this book will also be useful for Pharm-D, M. Pharmacy, B.Sc. as well as M.Sc. chemistry and pharmaceutical chemistry students. The main objective of this book is to attract the undergraduate Pharmacy students and make them to understand the basic principles of Organic Chemistry which can be applied in Pharmaceutical Chemistry and Medicinal Chemistry. Thus the book is aimed to eliminate the inadequacy in teaching and learning of Organic Chemistry by providing detailed information about the Organic compounds.

Salient Features:

- As per PCI Revised syllabus the coverage is complete with the basics as well as B. Pharm. 2nd, 3rd and 4th Semesters portion.
- The content of this book is innovative and presented in 31 chapters with simple and uniform pattern of explanation along with all chemical reactions.
- The book has covered the entire Pharmaceutical organic chemistry, starts from origin of organic chemistry to Heterocyclic chemistry and Stereochemistry.
- In each chapter, a brief Introduction of the individual chapter, Importance, Detailed discussion of the Basic Theory, Preparations, Reactions, Test for identification and Applications of each class of compounds in Pharmacy are described which reflects the title of the book "Pharmaceutical Organic Chemistry".
- The principles of Organic Chemistry, which is difficult to remember by the students is described in a student friendly manner and shall be reproduced well in examinations.
- To make the learning comfortable and magnetize the attention we have used color in equations and diagrams.
- To inspire the readers, Interesting facts about great scientists and organic compounds and their discovery are given under each chapter.

About the Author

Dr. V. Alagarsamy, M. Pharm., PhD, FIC, DOMH, is Professor and Principal of MNR College of Pharmacy, Sangareddy, Gr. Hyderabad. He received his D.Pharm., from Coimbatore Medical College, B.Pharm., degree from Madurai Medical College, M.Pharm., from LM College of Pharmacy, Ahmedabad, PhD from The MS University of Baroda. He has been teaching Pharmaceutical Organic Chemistry, Pharmaceutical Inorganic Chemistry, Chemistry of Natural Products and Medicinal Chemistry and performing research work in synthetic medicinal chemistry on novel heterocyclic bio-active compounds for two decades. For his research work, he has collaborated with various research laboratories/organizations like National Cancer Institute, USA; Rega Institute for Medical Research, Belgium; Southern Research Institute, USA; and Sudbury Regional Hospital, Ontario, Canada. He is a recipient of young scientist award from the Department of Science and Technology, New Delhi. He is the author/coauthor of over 160 papers, which includes the original research articles and presentations in various conferences and symposiums. He has also patented his Research findings. He become the co-editor of the International journal **"Antiinfective Agents"**, published by Bentham Science Publishers. His Books on the title of "**Text Book of Medicinal Chemistry**," "**Pharmaceutical Chemistry of Natural Products**," "**Pharmaceutical Inorganic Chemistry**," "**Organic Chemistry - A Comprehensive Approach**"and "**Practical Pharmaceutical Inorganic Chemistry**" are well appreciated in the academic community. His research activities are supported by the funding agencies like CSIR, DST and DSIR. Dr. V. Alagarsamy is a member of All India Board of Pharmaceutical Education (AIB-PE), AICTE, New Delhi and a member of board of studies (Pharmacy) in Osmania University, Hyderabad and is a doctoral committee member and a recognized research guide for PhD scholars in various universities.

PharmaMed Press

An Imprint of Pharma Book Syndicate

A Unit of **BSP Books Pvt. Ltd.**

4-4-309/316, Giriraj Lane, Sultan Bazar, Hyderabad - 500 095.
Phone: 040 - 23445688, 23445600, Fax: 91+40-23445611

E-mail: info@pharmamedpress.com, info@bspbooks.net
www.pharmamedpress.com; pharmamedpress.net

ISBN : 978-93-89354-77-5

Chemistry