

Chapter 1

Nomenclature of Heterocyclic Compounds

A cyclic organic compound containing all carbon atoms in ring formation is referred to as a *carbocyclic compound*. If at least one atom other than carbon, forms a part of the ring system then it is designated as a *heterocyclic compound*.¹⁻¹⁵ Nitrogen, oxygen and sulfur are the most common heteroatoms but heterocyclic rings containing other hetero atoms are also widely known. An enormous number of heterocyclic compounds are known and this number is increasing rapidly. Accordingly the literature on the subject is very vast. Heterocyclic compounds may be classified into *aliphatic* and *aromatic*. The aliphatic heterocyclics are the cyclic analogues of amines, ethers, thioethers, amides, etc. Their properties are particularly influenced by the presence of strain in the ring. These compounds generally consist of small (3- and 4- membered) and common (5 to 7 membered) ring systems. The aromatic heterocyclic compounds, in contrast, are those which have a heteroatom in the ring and behave in a manner similar to benzene in some of their properties. Furthermore, these compounds also comply with the general rule proposed by Hückel. *This rule states that aromaticity is obtained in cyclic conjugated and planar systems containing $(4n + 2) \pi$ electrons.* The conjugated cyclic rings contain six π -electrons as in benzene, and this forms a conjugated molecular orbital system which is thermodynamically more stable than the non-cyclically conjugated system. This extra stabilization results in a diminished tendency of the molecule to react by addition but a larger tendency to react by substitution in which the aromatic ring remains intact.

A heterocyclic ring may comprise of three or more atoms which may be saturated or unsaturated. Also the ring may contain more than one hetero atom which may be similar or dissimilar.

The chemistry of heterocyclic compounds is as logical as that of aliphatic or aromatic compounds. Their study is of great interest both from the theoretical as well as practical standpoint. Heterocyclic compounds occur widely in nature and in a variety of non-naturally occurring compounds. A large number of heterocyclic compounds are essential to life. Various compounds such as alkaloids, antibiotics, essential amino acids, the vitamins, haemoglobin, the hormones and a large number of synthetic drugs and dyes contain heterocyclic ring systems. A knowledge of heterocyclic chemistry is useful in biosynthesis

and in drug metabolism as well. Nucleic acids are important in biological processes of heredity and evolution.

There are a large number of synthetic heterocyclic compounds with additional important applications and many are valuable intermediates in synthesis.

1.1 NOMENCLATURE¹⁴

In heterocyclic chemistry there is a special name for each individual ring system and a trivial name for each compound. Trivial names convey little or no structural information but they are still widely used. The systematic name, in contrast, is designed so that one may deduce from it the structure of the compound. They tend to be long. However, a systematic nomenclature is still indispensable.

In recent years the International Union of Pure and Applied Chemistry (IUPAC) has made efforts to systematize the nomenclature of heterocyclic compounds.

According to this system single three-to-ten-membered rings are named by combining the appropriate *prefix* or *prefixes* (listed in Table 1.1) with a stem from Table 1.2.

Table 1.1 Prefix for Hetero Atoms

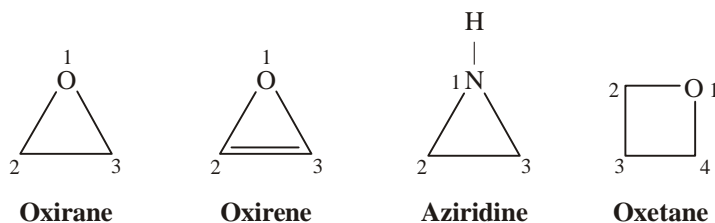
<i>Hetero atom</i>	<i>Valence</i>	<i>Prefix</i>
O	2	Oxa
N	3	Aza
S	2	Thia
Se	2	Selena
Te	2	Tellura
P	3	Phospha
As	3	Arsa
Si	4	Sila
Ge	4	Germa

Table 1.2 Common Name Endings for Heterocyclic Compounds

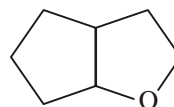
<i>Ring size</i>	<i>Suffixes for fully unsaturated compounds</i>		<i>Suffixes for fully saturated compounds</i>	
	<i>With N</i>	<i>Without N</i>	<i>With N</i>	<i>Without N</i>
3	-irine	-irene	-iridine	-irane
4	-ete	-ete	-etidine	-etane
5	-ole	-ole	-olidine	-olane
6	-ine	-in		-ane
7	-epine	-epin		-epane
8	-ocine		-ocin	-ocane

The endings in Table 1.2 also indicate the size of the ring and the state of hydrogenation with or without the presence of a nitrogen atom.

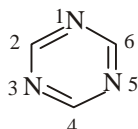
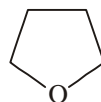
Accordingly some examples of compounds named on the basis of above two tables are cited below:



In all these examples the letter 'a' has been omitted. However, in the following cases letter 'a' has been retained.

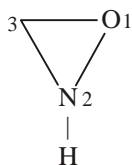
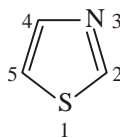
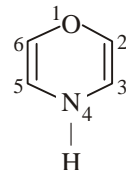
**Azacyclobutadiene****2-Oxabicyclo [3.3.0] Octane**

Saturated or hydrogenated ring systems are named by varying the ending or by placing prefixes such as '*dihydro-*', '*tetrahydro-*', etc. The ending of the name will depend on the presence or absence of nitrogen (Table 1.2).

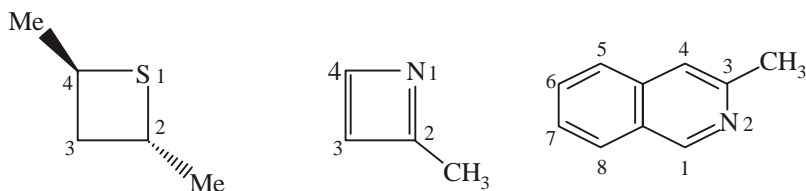
**1,3,5-Triazine****Tetrahydrofuran**

Two or more similar atoms contained in a ring are indicated by the prefixes '*di-*', '*tri-*', etc. placed before the appropriate 'a' term (Table 1.2).

If two or more different hetero atoms occur in the ring, then it is named by combining the prefixes in Table 1.1 with the ending in Table 1.2 in order of their preference, i.e. O, S and N. This is illustrated by the following examples:

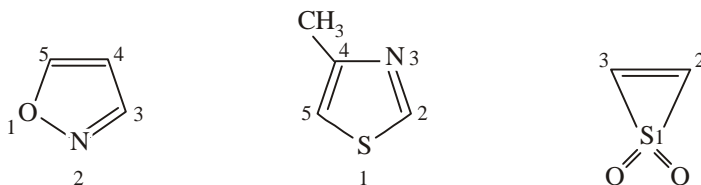
**Oxaziridine****Thiazole****1,4-Oxazine**

The position of a single hetero atom controls the numbering in a monocyclic compound but not necessarily in a bicyclic compound.



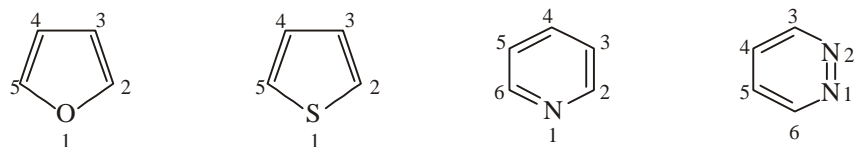
***trans*-2,4-Dimethylthietane 2-Methylazete 3-Methylisoquinoline**

Numbering of the heterocyclic rings becomes essential when substituents are placed on the ring. Conventionally, the hetero atom is assigned position 1 and the substituents are then counted around the ring in a manner so as to give them the lowest possible numbers. While writing the name of the compound, the substituents are placed in an alphabetical order. In case the heterocyclic ring contains more than one hetero atom, the order of preference for numbering is O, S and N. The ring is numbered from the atom of preference in such a way so as to give the smallest possible number to the other hetero atoms in the ring. As a result the position of the substituent plays no part in determining how the ring is numbered in such compounds. The following examples illustrate this rule:

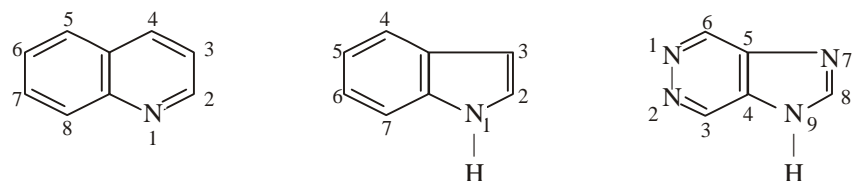


1,2-Isoxazole 4-Methylthiazole Thiirene 1,1-dioxide

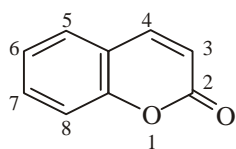
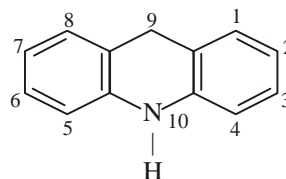
There are a large number of important ring systems which do not possess any systematic names rather non-systematic or common names are used for them. Some of such examples include the following:



Furan Thiophene Pyridine Pyridazine

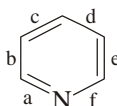


Quinoline Indole Purine

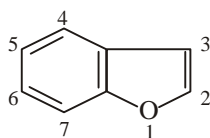
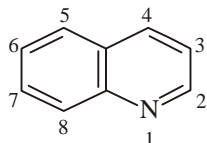
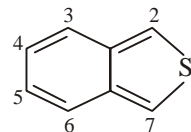
**Coumarin****Acridine**

The numbering and nomenclature of heterocyclic rings become more complicated for condensed or fused ring systems, i.e., when a part of one ring is also a part of another ring. Such ring systems, however, are known by non-systematic or common names, such as indole, isatin, isoquinoline, etc., as indicated in the preceding paragraph.

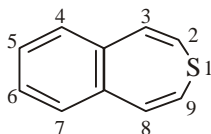
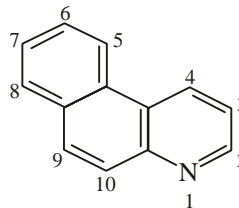
There is yet another system of nomenclature for fused rings that is commonly employed. According to this system, the side of the heterocyclic ring is labelled by the letters a, b, c, etc., starting from the atom numbered 1. Therefore side 'a' being between atoms 1 and 2, side 'b' between atoms 2 and 3, and so on as shown below for pyridine.

**Pyridine**

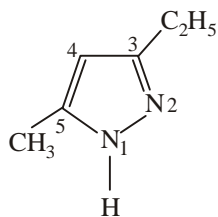
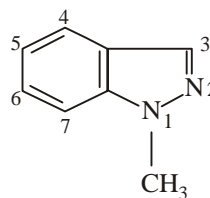
The name of the heterocyclic ring is chosen as the parent compound and the name of the fused ring is attached as a prefix. The prefix in such names has

**Benzo [b] furan****Benzo [b] pyridine****Benzo [c] thiophene**

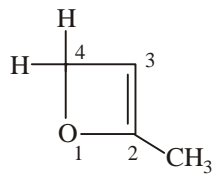
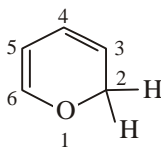
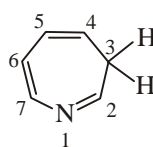
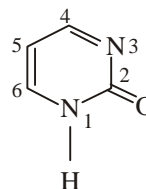
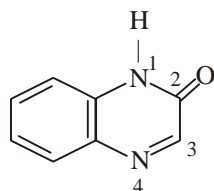
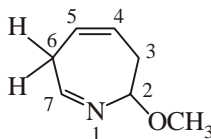
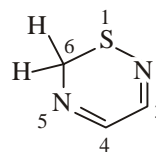
the ending 'o', i.e., benzo, naphtho and so on. The following examples explain this rule.

**Benzo [d] thiepin****Benzo [f] quinoline**

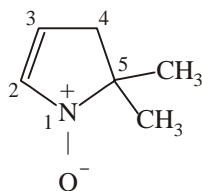
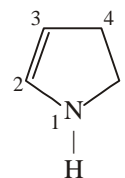
In a heterocyclic ring, other things being equal, numbering preferably commences at a saturated rather than at an unsaturated hetero atom, as depicted in the following examples:

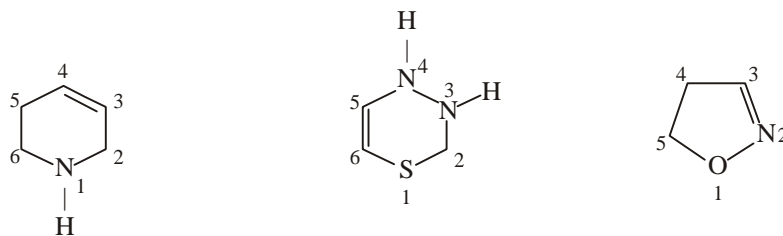
**3-Ethyl-5-methylpyrazole****1-Methylindazole**

In a heterocyclic ring with maximum unsaturation, if the double bonds can be arranged in more than one way, then their positions are specified by numbering those nitrogen or carbon atoms which are not multiply-bonded, i.e. bear an 'extra' hydrogen atom, by italic capital '1*H*' '2*H*' '3*H*', etc. The numerals indicate the position of these atoms having the extra hydrogen atom. The following examples illustrate this rule:

**2-Methyl-4*H*-Oxete****2*H*-Pyran****3*H*-Azepine****2(1*H*)-Pyrimidinone****Quinoxaline-2(1*H*)-one****2-Methoxy-6*H*-azepine****6*H*-1,2,5-Thiadiazine**

The position of the hydrogen atom in a partially saturated heterocyclic ring can be indicated by writing 1, 2-dihydro, etc. with the name of the compound. Alternatively, the position of the double bond can also be specified as Δ^1 , Δ^2 , Δ^3 , etc., which indicates that 1 and 2; 2 and 3; 3 and 4 atoms respectively have a double bond.

**5,5-Dimethyl- Δ^2 -pyrroline N-oxide** **Δ^2 -Pyrroline**

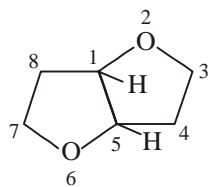


Δ^3 -Tetrahydropyridine Δ^5 -Dihydro-1,3,4-thiadiazine Δ^2 -Oxazoline

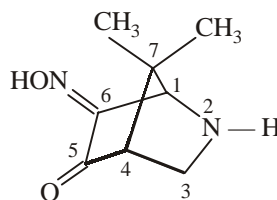
A positively charged ring is denoted by the suffix “-ium”.

Groups such as C = S and C = NH present in the ring are denoted by the suffixes “-thione” and “-imine”.

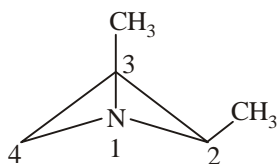
Bicyclic bridged structures are quite common in heterocyclic chemistry. The nomenclature of such a structure consists of the prefix bicyclo, followed in square brackets the number of carbon atoms separating the bridge heads by the three possible routes in descending numerical order. This is followed by the alkane containing the same number of carbon as the whole bicyclic heterocyclic skeleton. The following examples illustrate the use of this rule.



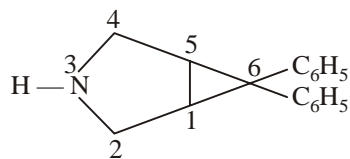
3,6-Dioxabicyclo [3.1.0] octane



6-Hydroxyimino-7,7-dimethyl-2-azabicyclo [2.2.1] heptan-5-one



2,3-Dimethyl-1-azabicyclo [1.1.0] butane



6,6-Diphenyl-3-azabicyclo [3.1.0] hexane.

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