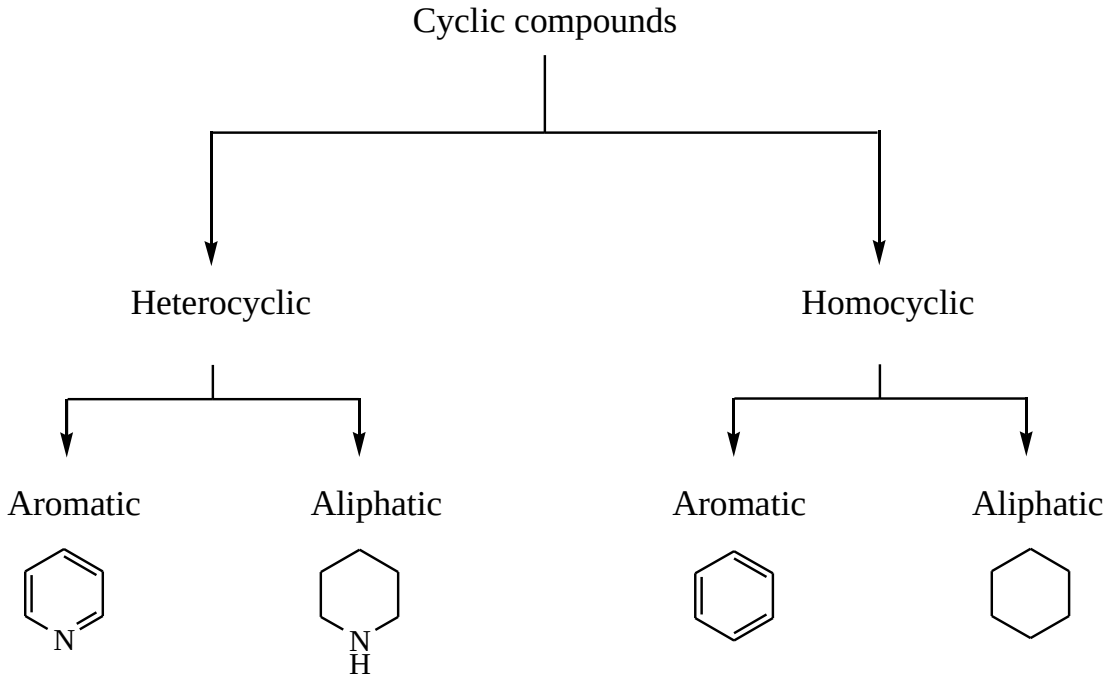
1) Heterocyclic compounds :

A heterocyclic compound is one that contains a ring made up of more than one kind of atoms (like O , S , N) beside carbon atoms.
The most important rings are the five – and six – membered heterocycles.

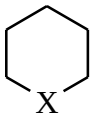
The following scheme illustrates the classification of cyclic compounds:



Heterocyclic compounds may be classified into two types:

1- The aliphatic heterocycles: which are the cyclic analogues of amines, ethers, esters and thioesters, their properties are influenced by ring strain. They react largely like their aliphatic analogues.

e.g.



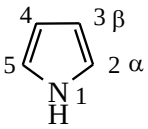
X= O ⟹ oxane reacts as dialkyl ethers
X= S ⟹ thiane reacts as dialkyl sulfides
X= NH ⟹ piperdine reacts as secondary aliphatic amines

2- The aromatic heterocycles: which shows aromatic behavior as in benzene. These compounds follow the Huckel's rule which states that " cyclic conjugated and planar systems having (4n+2) π

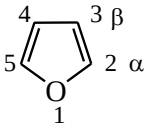
electrons are aromatic ", these compounds can be classified into two types:

a- This type is the same as in cyclopentadiene with replacing (CH_2) group by hetero atom like (O , S , N), in which the unshared pair of electrons will be a part of the aromatic sextet.

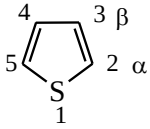
e.g.:



Pyrrole

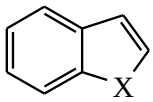


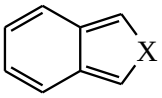
Furan

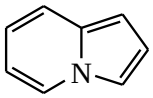


Thiophene

Monocyclic system







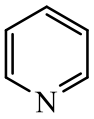
Bicyclic system

X= NH Indole
X= O Benzofuran
X= S Benzothiophene

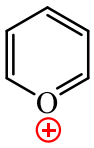
Isoindole
Isobenzofuran
Isobenzothiophene

Indolizine

b- The second type is the same as in benzene with the replacement of (- CH_2=) unit by hetero atom like (N) as in pyridine, or (O) atom as in pyrylium salts.

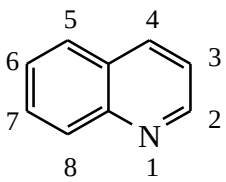


Pyridine

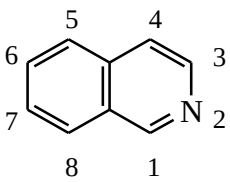


Pyrylium cation

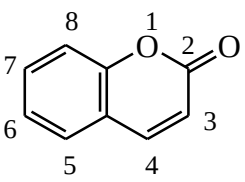
As in five membered heterocycles; six membered heterocyclic compounds may exist as monocyclic system as mentioned above or as bicyclic system as the following:



Quinoline

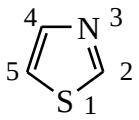


Isoquinoline

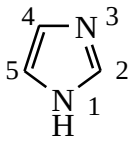


Coumarin

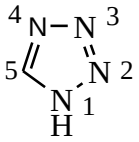
Furthermore heterocyclic compounds may contain more than one hetero atom which could be of the same type or different type, and here again they could be five or six membered ring system which either mono or bi cyclic systems.



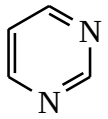
Thiazole



Imidazole

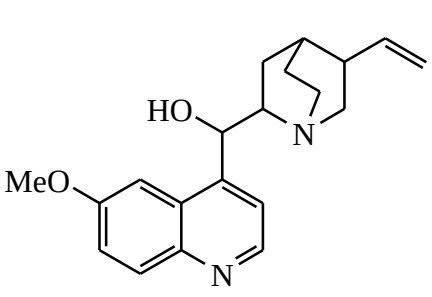


Tetrazole

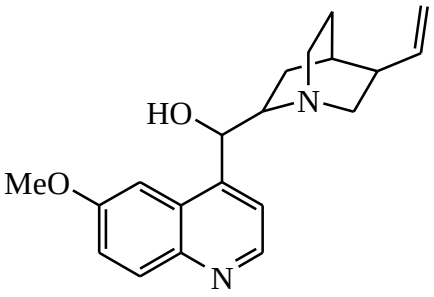


Pyrimidine

Significance: Two third of all organic compounds are aromatic heterocycles. Most pharmaceuticals are heterocycles like quinine which used as antimalarial drug.



or



Quinine

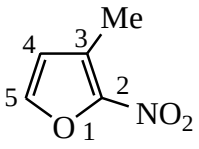
Many heterocyclic compounds occur naturally and are actively involved in biology e.g. nucleic acids (purine and pyrimidine bases), vitamins (B_1, B_2, B_3, B_6 and C), penicillins, chlorophyll ……..etc.
The study of hrterocyclic chemistry is a vast and expanding area of chemistry because of their applications in medicine, agriculture and other fields.

2) Systematic nomenclature of heterocyclic compounds:

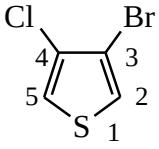
The derivation of systematic name is based on its structure. The IUPAC rules allow two nomenclatures. The Hantzsch – Widman method is recommended for three – to ten – membered ring system.
For larger ring heterocycles, replacement nomenclature should be used.

Simply, in five membered ring system numbering start from the hetero atom and proceed in a manner that the substituents takes the lowest possible number. (note: substituents names should be written alphabetically).

e.g.

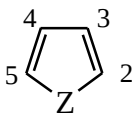


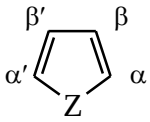
3-methyl-2-nitro furan



3-bromo-4-chloro thiophene

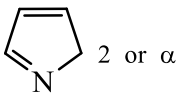
Latin letters can be also used instead of numbers to indicate the substituent position:



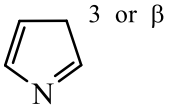


Z= O, S, N

Nomenclature of these compounds is also depend on the position of the double bonds, for example pyrrole exist in two tautomeric forms *2H*-pyrrolenine and *3H*-pyrrolenine:

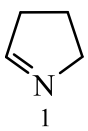


2H-pyrrole

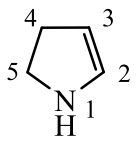


3H-pyrrole

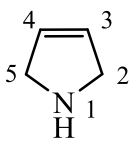
Furthermore partially saturated dihydropyrroles are called pyrrolines, three of these namely Δ^1 – , Δ^2 – and Δ^3 – pyrrolines are possible. The fully saturated pyrrole is designated as pyrrolidine.



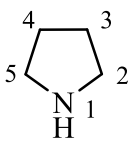
Δ^1–pyrroline
or
3,4-dihydro-2H-pyrrole



Δ^2–pyrroline
or
4,5-dihydro-1H-pyrrole



Δ^3–pyrroline
or
2,5-dihydro-1H-pyrrole



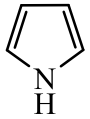
pyrrolidine

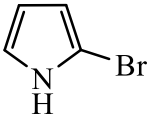
Note: (Δ) refer to the double bond position.

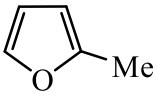
General examples:

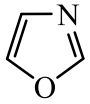

Furan


Thiophene

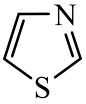

Pyrrole

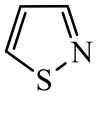

2-Bromo pyrrole

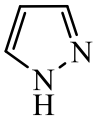

2-Methyl furan

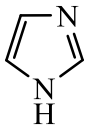

Oxazole

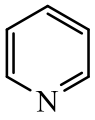

Isoxazole

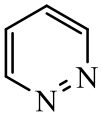

Thiazole

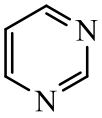

Isothiazole

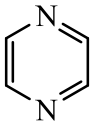

Pyrazole

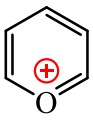

Imidazole

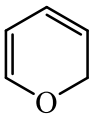

Pyridine

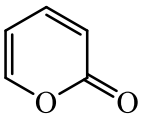

Pyridazine

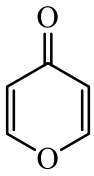

Pyrimidine


Pyrazine


Pyrylium cation


2H-pyrane


α or 2- pyrone

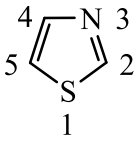

γ or 4- pyrone

On the other hand the replacement method can be summarized as the following:

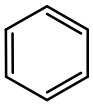
a- The hetero atom is indicated by a prefix:
O= oxa , S= thia , N= aza

b- *Position and prefix for each hetero atom are written in front of the name of the corresponding hydrocarbon.*
This is derived from the heterocyclic system by replacing every hetero atom by CH_2, CH or C:

Cyclopentadiene

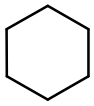


1-Thia-3-azacyclopenta-2,4-diene

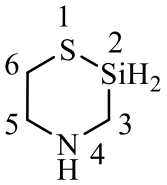


Benzene

Az



Cyclohexane



1-Thia-4-aza-2-

Sequence and numbering follow the rules in Hantzch – Widman method in which:

1) The hetero atom sequence:
   O > S > Se > Te > N > P > As > Sb > Bi > Si ……
2) Numbering start from the hetero atom taking in our account the above sequence.