Nomenclature of heterocyclic compounds:

There are three systems for naming heterocyclic compounds:

1-Common Nomenclature

1) Each compound is given the corresponding trivial name (which should be memorized). This usually originates from the compounds occurrence, its first preparation or its special properties.

2) If there is more than one heteroatom of the same type numbering starts at the saturated one, e.g. imidazole.

3) If there is more than one type of the heteroatoms, the ring is numbered starting at the heteroatom of the higher priority (O>S>N) and it continues in the direction to give the other heteroatoms the lower numbers as possible.

4) If substituents are present, their position should be identified by the number of the atoms bearing them and then they should be listed in alphabetical order.

5-Amino-4-bromoisoazole
5) The words dihydro, or trihydro, or tetrahydro are used if two or three or four atoms are saturated. These words are preceded by numbers indicate the position of saturated atoms as low as possible and followed by the corresponding fully unsaturated trivial name.

\[
\begin{align*}
&\text{1,2-Dihydro-pyridine} \\
&\text{Trivial names}
\end{align*}
\]

1) Five - Membered heterocycles with one or two heteroatoms

2) Six-membered heterocycles with one or two heteroatoms

Common azines-six-membered aromatic nitrogen heterocycles

<table>
<thead>
<tr>
<th>Furan</th>
<th>Thiophene</th>
<th>Pyrrole</th>
<th>Imidazole</th>
<th>Pyrazole</th>
<th>Isoxazole</th>
<th>Oxazole</th>
<th>Thiazole</th>
</tr>
</thead>
</table>

2H-Pyran 4H-Pyran Pyridine Pyridazine Pyrimidine Pyrazine DNA/RNA bases

These are tautomers
Both are not aromatic
3) Fused heterocycles

**common ring-fused azoles**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indole</td>
<td><img src="structure1.png" alt="Indole" /></td>
</tr>
<tr>
<td>Isoindole</td>
<td><img src="structure2.png" alt="Isoindole" /></td>
</tr>
<tr>
<td>Indazole</td>
<td><img src="structure3.png" alt="Indazole" /></td>
</tr>
<tr>
<td>Purine</td>
<td><img src="structure4.png" alt="Purine" /></td>
</tr>
<tr>
<td>Indolizidine</td>
<td><img src="structure5.png" alt="Indolizidine" /></td>
</tr>
</tbody>
</table>

Indole (found in the amino acid tryptophan)

**common ring-fused azines**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quinoline</td>
<td><img src="structure6.png" alt="Quinoline" /></td>
</tr>
<tr>
<td>Isoquinoline</td>
<td><img src="structure7.png" alt="Isoquinoline" /></td>
</tr>
<tr>
<td>Quinazoline</td>
<td><img src="structure8.png" alt="Quinazoline" /></td>
</tr>
<tr>
<td>Pteridine</td>
<td><img src="structure9.png" alt="Pteridine" /></td>
</tr>
<tr>
<td>Quinolizidine</td>
<td><img src="structure10.png" alt="Quinolizidine" /></td>
</tr>
</tbody>
</table>

Quinazoline (found in the B vitamin riboflavin)

**Additional Structures**

- Coumarine
- Chromen-2-one
- Chromen-4-one
- Flavone
- 9H-Carbazole
- 9,10-Dihydro-acridine
4) Saturated heterocycles

- Pyrrolidine
- Piperidine
- Piperazine
- Morpholine

1,2,3,4-tetrahydropyrimidine
Tetrahydrofuran
3-bromomorpholine
5-bromoxazole

2-Replacement nomenclature

In replacement nomenclature, the heterocycle’s name is composed of the corresponding carbocycle’s name and an elemental prefix for the heteroatom introduced (if more than one heteroatom is present they should be listed according to the priority order shown in (table 1). According to this nomenclature, tetrahydrofuran, for instance, is called oxacyclopentane.
Then, to name this compound by the replacement method:

1) See the corresponding carbocyclic name

\[
\begin{array}{c}
\text{Cyclopentadiene} \\
\end{array}
\]

2) Add the elemental prefixes for the heteroatoms introduced (in this case \(O=\text{oxa}\) \(N=\text{aza}\)

\[
\begin{array}{c}
\text{Oxa aza cyclopentadiene} \\
\end{array}
\]

3) Number all the heteroatoms and double bonds

\[
\begin{array}{c}
1-\text{Oxa-3-azacyclopenta-2,4-diene} \\
\end{array}
\]
Example:

![benzene](image)

1,4-Diazabenzene

Example

![Cyclopentadiene](image)

Oxacyclopenta-2,4-diene

Cyclopropene

Oxazacyclopene

Cyclopentadiene

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

Cyclohexane

1-Oxa-4-azacyclohexane

Naphthalene

2-Azanaphthalene
Hantzsch-Widman nomenclature (IUPAC)

Hantzsch-Widman nomenclature is named after the German chemists Arthur Hantzsch and Oskar Widman, who proposed similar methods for the systematic naming of heterocyclic compounds in 1887 and 1888 respectively. According to this system three to ten-membered rings are named by combining the appropriate prefix (or prefixes) that denotes the type and position of the heteroatom present in the ring with suffix that determines both the ring size (depending on the total number of atoms in the ring) and the degree of unsaturation (note that fully saturated and fully unsaturated have certain rules for nomenclature while partially unsaturation will be indicated in certain ways). In addition, the suffixes distinguish between nitrogen-containing heterocycles and heterocycles that do not contain nitrogen.

Hantzsch-Widman rules for fully saturated and fully unsaturated heterocycles

1) Identify the heteroatom present in the ring and choose from (table 1) the corresponding prefix e.g. thia for sulfur, aza for nitrogen.

2) The position of a single heteroatom control the numbering in a monocyclic compound. the heteroatom is always assigned position 1 and
if substituents present are then counted around the ring in a manner so as to take the lowest possible numbers.

Example

3) A multiplicative prefix (di, tri, etc.) and locants are used when two or more similar heteroatoms contained in the ring (two nitrogen indicated by diaza) and the numbering preferably commenced at a saturated rather than an unsaturated atom as depicted in the following example: 1,3-diaza...

4) If more than one type of heteroatoms present in the ring the name will include more than one prefix with locants to indicate the relative position of the heteroatoms. Atom prefixes have a strict order of priority (preference) in which they are to be listed. For example, oxa (for oxygen) always comes before aza (for nitrogen) in a name (see table 1). When combining the prefixes (e.g. oxa and aza) two vowels may end up together, therefore the vowel on the end of the first part should be omitted (oxaza).

The numbering is started from the heteroatom of the highest priority in such a way so as to give the smallest possible numbers to the other heteroatoms in the ring (the substituents are irrelevant). For example, the prefix corresponding to the following compounds is 4-methyl-1, 3-thiaza..

5) Choose the appropriate suffix from (table) depending on whether or not nitrogen atom is present in the ring, the size of the ring and presence or absence of any double bonds.

6) Combine the prefix (s) and suffix together and drop the first vowel if two vowels came together.
- This ring contains nitrogen = aza

- And saturated 3-membered ring with nitrogen = iridine

- By combining the prefix and suffix, two vowels ended up together (azairidine), therefore the vowel on the end of the first part should be dropped.

- The name = Aziridine

\[
\text{HN-O}
\]

. 1,2-oxazetidine

- This ring contains nitrogen = aza
• And oxygen = oxa
• And saturated 4-membered ring with nitrogen = etidine
• Drop the vowels in oxa and aza.
• The name = 1,2-oxazetidine

\[ \text{N} \quad \text{O} \quad \text{N} \]

, 1,2,5-oxadiazole

• This ring contains nitrogen = aza
• And oxygen = oxa
• And unsaturated five-membered ring with nitrogen = ole
• Oxygen is higher priority than nitrogen, so it is in position 1
• The two nitrogens are therefore at positions 2 and 5
• The name = 1,2,5-Oxadiazole

\[ \text{O} \quad \text{S} \]

, 1,3-oxathiolane

• This ring contains Sulpher = thia
• And oxygen = oxa
• And saturated five-membered ring without nitrogen = olane
• Oxygen is higher priority than sulphur, so it is in position 1
• Drop the vowel in thia
• The name = 1,3-Oxathiolane
**Hantzsch-windman rules for partially unsaturated heterocycles:**

1) The position of nitrogen or carbon atoms which bear extra hydrogen atoms must be indicated by numbers and italic capital H (e.g. 1H, 2H, etc.) followed by the name of maximally unsaturated ring.

![1H-Azepine](image1)  
**1H-Azepine**  

![5H-1,2,3-Oxathiazole](image2)  
**5H-1,2,3-Oxathiazole**  

![4H-Oxin](image3)  
**4H-Oxin**

2) The word dihydro or trihydro or tetrahydro are used if two or three or four atoms are saturated. These words are preceded by numbers indicating the position of saturated atoms as low as possible and followed by the corresponding fully unsaturated Hantzsch-Widman name.

![1,2-Dihydroazine](image4)  
**1,2-Dihydroazine**  

![1,4-Dihydroazine](image5)  
**1,4-Dihydroazine**  

![2,3,4,5-Tetrahydroazine](image6)  
**2,3,4,5-Tetrahydroazine**  

![2,3-Dihydrooxole](image7)  
**2,3-Dihydrooxole**  

Isomers have the same M.F. but differ in the position of the double bond.

3) *In the case of 4- and 5-membered rings, a special termination is used for the structures containing one double bond, when there can be more than one non-cumulative double bond.*

<table>
<thead>
<tr>
<th>No. of members of the partly saturated rings</th>
<th>Rings containing nitrogen</th>
<th>Rings containing no nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>-etine</td>
<td>-etene</td>
</tr>
<tr>
<td>5</td>
<td>-oline</td>
<td>-olene</td>
</tr>
</tbody>
</table>
Name = $\Delta^x$ +prefix + special suffix

$X$= locant of the double bond

Nomenclature of Fused Systems

Nomenclature of benzofused compounds:

Fusion: This term is used to describe the process of joining two separate rings with the maximum number of non-cumulative double bonds via two atoms and one common bond.

*Ortho-fused* rings: are those rings that have only two common atoms and one bond, example; naphthalene
**Nomenclature of benzofused compounds:**
A benzene ring fused to a heteromonocycle of five or more members or a heterobicycle is named by prefixing the word benzo to a letter indicating the position of fusion in square brackets by the name of heterocyclic ring (common or IUPAC or modified replacement name).

**Name = Benzo[letter]name of heterocyclic ring**
For designating the position of fusion, the peripheral bonds of the heterocyclic ring are consecutively assigned alphabetical letters staring with the 1,2-bond as a side and the labeling is continued around the ring to give the common bond the lowest order.

**Nomenclature of fused heterocyclic compounds**
Naming a fused heterocyclic system composed of two mono heterocyclic units or benzo heterocycles (e.g. chromene) fused with another heterocycle ring is based upon considering one system as the parent (base) and the second is considered as substituent.

**The name is formed of:**
name of minor ring [number, number-letter] name of major ring
The name of the minor ring is derived by writing a contracted prefix for the substituent ring present.
The numbers indicate which atoms in the minor ring are common to the major ring (fusion sites in minor ring). The order of the numbers indicates which atom of the minor ring is encountered closest to atom 1 in the major numbering system (i.e. these numbers may be written in ascending or descending order e.g. 2,3 or 3,2).

The letter defines the position of attachment of the minor ring to the major ring (fusion sites in base component).

Finally, a suffix indicates the name of the base ring is written. The numbering system for the whole fused system is not the same as the numbers in the square brackets (i.e. there are three numbering systems; one for minor ring, one for major ring and the third is for the system as a whole).

**Priority order of component ring systems:**

**Rule 1:**

A heterocyclic ring containing the heteroatom occurring ear list in the order N, F, Cl, Br, I, O, S, Se...(i.e. ring containing N preferred to the rings does not contain N or containing O, or S) is based on the following rules which are applied in order.
Rule 2:

A heterocyclic component containing the largest possible individual ring

2H-Furo[3,2-b]pyran
(pyran [6] preferred to furan [5])

Numbering the whole system is started from O in furan ring to give the two heteroatoms locants 1,4 while starting from O in pyran ring gives them locants 1,5, thus the indicated H takes locant 2

Rule 3:

A heterocyclic component containing the greater number of heteroatoms of any kind

5H-Pyrido[2,3-d][1,2]oxazine
(Oxazine preferred to pyridine)
Note. The whole molecule is numbered starting from pyridine ring to give the three heteroatoms the lowest locants (1,6,7), however, stating from oxazine ring will give them locants (2,3,5) or (2,3,8).

Rule 4: A heterocyclic component containing the greater variety of heteroatoms

![1H-Pyrazolo[4,3-d]oxazole](image)

(O & N preferred to N only)

Note. The whole molecule is numbered starting from pyrazole ring to give the four heteroatoms the lowest locants (1,2,4,6). While starting from oxazole ring give them locants (1,3,4,5) or (1,3,5,6)

Rule 5:
A component with the lower locants for heteroatoms. Example:

![Pyrazino[2,3-d]pyridazine](image)

(pyrindazine [2N-1,2] preferred to pyrazine [2N-1,4])

Rule 6:
A component containing the greater number of heteroatoms most preferred when considered in the order F, Cl, Br, I, O, S, Se, Te, N, P, As, Sb, Bi, Si, Ge, Sn, Pb, B, Hg

![1,3|Thiazolo[5,4-d][1,3]oxazole](image)

(N & O preferred to N & S)
Rule 7:
If a position of fusion is occupied by a heteroatom the name of the component rings to be used are so chosen as both to contain the heteroatom.

\[
\text{Imidazo}[2,1-b]\text{thiazole}
\]