Chapter 3: Nomenclature

Lesson 3.1 – IUPAC Basics and Naming Alkanes

Naming Alkanes
1. Find the parent chain, the longest carbon chain. If two possible parent chains have the same length, but different substituent numberings, pick the one with the smaller substituent number at the first point of difference.
2. Count the number of carbon atoms in the parent chain and match that number to the name from our earlier chart (methane, ethane, propane, etc.)
3. Identify and number the substituents (appendage dangling off the parent chain) in whichever direction gives them the lowest number.
4. Write the name as a single word with the substituents in alphabetical order.

Lesson 3.2 – Naming Cycloalkanes and Alkyl Halides

Naming Cycloalkanes
1. When there are two substituents on a cyclic molecule, their direction must be indicated with prefix “cis”, meaning “same side”, or “trans”, meaning “opposite sides”.

![cis-1-ethyl-2-methylcyclohexane](image)

2. If there are more than two substituents, “cis” and “trans” are no longer enough, and these substituents must be named with their stereochemical configurations (R/S system).

![cis-1,3-ethyl-2,3-dimethylcyclohexane](image)

Naming Alkyl Halides
When naming alkyl halides, we follow the same rules for naming alkanes, except that we use prefixes “fluoro-“, “chloro-“, “bromo-”, or “iodo-”, to identify each halogen substituent.
Lesson 3.3 – Naming Alkenes and Alkynes

Naming Alkenes
1. Use suffix “-ene” instead of “-ane”.
2. Add a number at the start of the double bond.
3. Add prefixes “cis” or “trans” for alkenes with different priority substituents, and at least one hydrogen on either side of the alkene.
4. If all substituents are different, use the E/Z naming system, where E = highest priority substituents on opposite sides, and Z = highest priority substituents on the same side.

```
H3C
H     CH3
H     H
 cis-2-butene or trans-2-butene or cis-but-2-ene
```

Determining Priority
1. Highest atomic number = highest priority.
2. If there's a tie, keep going to adjacent carbons until you break the tie.
3. Multiple-bonded atoms are counted as the same number of single-bonded atoms:

```
H
\_C=O
This O is bonded to C, C.
H
```

Naming Alkynes
1. Use suffix “-yne” instead of “-ane”.
2. Add a number at the start of the triple bond.

```
H3C
CH3
hept-3-yne
```
Lesson 3.4 – Naming Alcohols, Ethers, and Amines

When naming **alcohols**, we follow the rules for naming alkanes, except:

1. The parent chain is now the longest chain that has the hydroxyl group, even if there are longer carbon chains available.
2. Number the carbon chain in the direction that gives the smallest number to the carbon bonded to the hydroxyl group.
3. Hydroxyl groups are higher priority than cycloalkanes, amines, alkenes, ethers, and alkyl halides, so they must be numbered according to the lowest-number carbon that is bonded to the hydroxyl group.
4. Change suffix “-e” to “-ol”.

When naming **ethers**:

1. Name the two alkyl groups as substituents with “ether” at the end:

   ![Methyl propyl ether](image1.png)
   ![Ethyl isopropyl ether](image2.png)

2. Consider the longest carbon chain to be the parent chain and the alkoxy group to be a substituent:

   ![Methoxy propane](image3.png)

When naming **primary amines**, add the suffix “amine” to the name of the organic substituent.

![Tert-butyl amine](image4.png)
![Cyclohexylamine](image5.png)

Symmetrical and **secondary amines** are named by adding “di-” or “tri-” to the alkyl group:

![Diethylamine](image6.png)
![Triethylamine](image7.png)
Lesson 3.5 – Naming Aldehydes and Ketones

When naming **aldehydes**, we follow the rules for naming alkanes with the addition of two rules:

1. We number the parent chain in the direction that gives highest priority (lowest number) to the aldehyde (carbonyl) carbon.
2. We replace “e” with “al”.

![Butanal, 4-Methylpentanal, Methanal (Formaldehyde)]

When naming **ketones**, we follow the same rules for naming alkanes, except:

1. Similar to aldehydes, the parent chain must be chosen with priority given to the ketone (carbonyl) carbon.
2. Replace the “e” with “one”.
3. The carbonyl carbon in a cyclic ketone is assumed to be the #1 carbon.

![3-Hexanone, 3,5-Dimethyl-2-Hexanone or 3,5-Dimethylhexan-2-One, Cyclohexanone]
Lesson 3.6 – Naming Carboxylic Acids and Derivatives

When naming carboxylic acids, we follow the rules for naming alkenes, except:

1. We number the parent chain in the direction that gives the highest priority (lowest number) to the carboxylic acid group.
2. We replace “ane” for “oic acid”.

![Examples of carboxylic acids]

When naming acid halides:

1. Follow the same rules as for carboxylic acids, and change the suffix to “oyl halide”.

![Examples of acid halides]

When naming esters:

1. The alkyl group attached to the ester oxygen gets listed first with the suffix “yl”. The parent chain then follows.
2. The parent chain starts at the carbonyl carbon and is counted moving away from the ester oxygen. Parent chain’s suffix is replaced with “oate”.

![Examples of esters]
Lesson 3.6 – Naming Carboxylic Acids and Derivatives (Continued)

When naming **amides**, we follow the same pattern of naming for **esters**, except:

1. Any alkyl groups attached to the nitrogen get listed as “N-methyl”, “N-ethyl”, “N-propyl” etc.
2. The parent chain starts at the carbonyl carbon and is counted moving away from the amide nitrogen.

![Amide Example](image)

**N-methylbutanamide**

When naming **acid anhydrides**:

1. Determine the length of the chain on either side of the bridging oxygen.
2. List both lengths alphabetically, replacing each suffix “e” with “oic”.
3. Write “anhydride” at the end of the name.

![Anhydride Example](image)

**butanoic ethanoic anhydride**

When naming **nitriles**, follow the same rules for naming alkanes, except:

1. The parent chain is the longest carbon chain that involves the nitrile carbon.
2. Number the parent chain in the direction that gives the smallest number to the nitrile carbon.
3. Add the suffix “nitrile” to the parent name.

![Nitrile Example](image)

**pentanenitrile**
Lesson 3.7 – Naming Aromatics

When naming substituted benzenes:
1. Identify the parent chain, which is the benzene containing the highest-priority functional group. That parent chain is the parent chain name.
2. The carbon atom in the ring that is attached to the priority functional group is numbered as carbon #1.
3. Number around the ring in whichever direction (clockwise or counterclockwise) that gives the lowest number at the first point of difference.
4. If the numbers are the same in both directions, pick the one that gives the lower number to the substituent that is alphabetically first.

chlorobenzene  nitrobenzene  ethylbenzene
Lesson 3.8 – Naming Polyfunctional Compounds

When naming poly-functional compounds:
1. You must identify the highest-priority functional group. The parent chain containing this functional group is the parent chain name.
2. Once you identify the parent chain and its functional group, follow the naming rules for that particular functional group. All other functional groups in the molecule are considered and named as substituents.

Priority of Functional Groups

<table>
<thead>
<tr>
<th>Functional group</th>
<th>Examples (if parent):</th>
<th>If it's a substituent to a higher-priority group, then it's called:</th>
</tr>
</thead>
<tbody>
<tr>
<td>R = any carbon chain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carboxylic acid (RCO₂H)</td>
<td>Ethanoic acid, propanoic acid, butanoic acid, etc.</td>
<td></td>
</tr>
<tr>
<td>Ester (RCO₂R')</td>
<td>Ethyl ethanoate, methyl propanoate, etc.</td>
<td>Alkoxycarbonyl</td>
</tr>
<tr>
<td>Acid chloride (RCO₂Cl)</td>
<td>Ethanoyl chloride, propanoyl chloride</td>
<td>Chloroformyl</td>
</tr>
<tr>
<td>Amide [R'N(C)=N]</td>
<td>N,N-dimethyl propanamide; N-ethylbutanamide</td>
<td>Amido</td>
</tr>
<tr>
<td>Nitrile (R–C≡N)</td>
<td>Ethenenitrile, propanenitrile, etc.</td>
<td>Cyano</td>
</tr>
<tr>
<td>Aldehyde ([C=O])</td>
<td>Ethanal, propanal, butanal, etc.</td>
<td>Oxo or formyl</td>
</tr>
<tr>
<td>Ketone ([C=O])</td>
<td>2-butanone, 3-butano, 2-pentanone</td>
<td>Oxo</td>
</tr>
<tr>
<td>Alcohol (ROH)</td>
<td>Methanol, ethanol, propanol, etc.</td>
<td>Hydroxy</td>
</tr>
<tr>
<td>Phenol (PhOH)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amine (R'-NR₂)</td>
<td>N,N-dimethylpropanamine, N-ethylcyclohexanamine</td>
<td>Amino</td>
</tr>
<tr>
<td>Alkene ([R–=C–R'])</td>
<td>Ethene, propene, butene, etc.</td>
<td></td>
</tr>
<tr>
<td>Alkyne ([R–≡C–R'])</td>
<td>Ethyne, propyne, butyne, etc.</td>
<td></td>
</tr>
<tr>
<td>Ether (R'OR)</td>
<td>Methoxyethane, ethoxypropane</td>
<td>methoxy, ethoxy, propoxy, etc.</td>
</tr>
<tr>
<td>Alkyl halide (RX) X = F, Cl, Br, or I</td>
<td>2-bromopropane, 3-chlorobutane, etc.</td>
<td>Fluoro, chloro, bromo, iodo, etc.</td>
</tr>
<tr>
<td>Nitro (NO₂)</td>
<td>N/A</td>
<td>Nitro</td>
</tr>
</tbody>
</table>