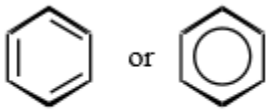
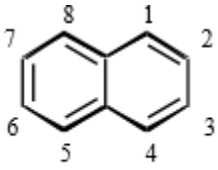
Nomenclature of Aromatic Compounds

- **"Aromatic" compounds are those derived from benzene and similar ring systems.**
- **As with aliphatic nomenclature described above, the process is: determining the root name of the parent ring; determining priority, name, and position number of substituents; and assembling the name in alphabetical order.**
- **Functional group priorities are the same in aliphatic and aromatic nomenclature**

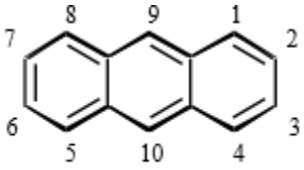
A. Common Parent Ring System



benzene



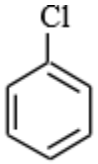
naphthalene



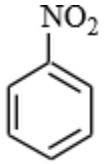
anthracene

B. Monosubstituted

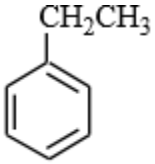
Benzenes 1. Most substituents keep their designation, followed by the word "benzene":



chlorobenzene

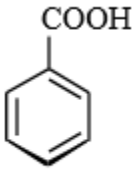


nitrobenzene

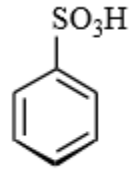


ethylbenzene

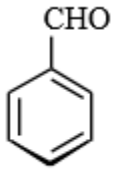
2. Some common substituents change the root name of the ring. IUPAC accepts these as root names, listed here in decreasing priority:



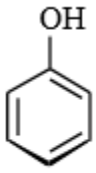
benzoic acid



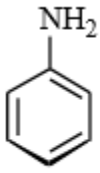
benzene-sulfonic acid



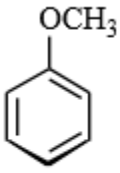
benzaldehyde



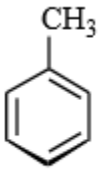
phenol



aniline



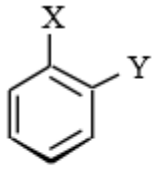
anisole

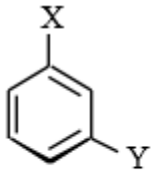


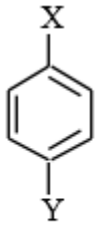
toluene

C. Disubstituted

Benzenes 1. Designation of substitution—only three possibilities:

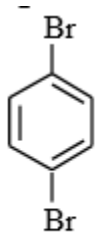




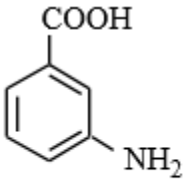


common:	*ortho-*	*meta-*	*para-*
IUPAC:	1,2-	1,3-	1,4-

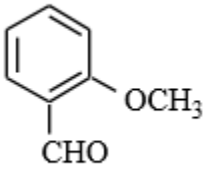
2. Naming disubstituted benzenes—Priorities determine root name and substituents



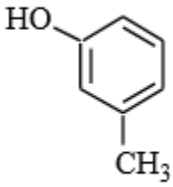
1,4-dibromobenzene



3-aminobenzoic acid

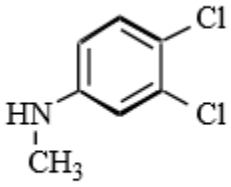


2-methoxybenzaldehyde

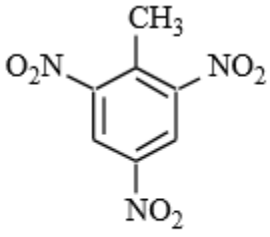


3-methylphenol

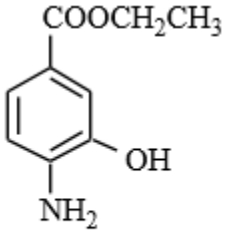
2. Naming disubstituted benzenes—Priorities determine root name and substituents



3,4-dichloro-*N*-methylaniline



2,4,6-trinitrotoluene (TNT)



ethyl 4-amino-3-hydroxybenzoate

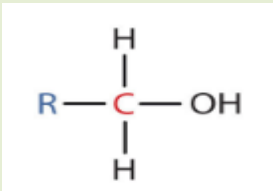
Some Common Alcohols

- **Methyl alcohol, CH3OH (methanol; wood alcohol)**
- **Ethyl alcohol, CH3CH2OH (ethanol; grain alcohol; "alcohol")**
- **Isopropyl alcohol, (CH3)2CHOH (isopropanol; 2-propanol; rubbing alcohol)**
- **Ethylene glycol, HOCH2CH2OH (1,2-ethanediol; antifreeze)**
- **Glycerol, HOCH2CH(OH)CH2OH (1,2,3-propanetriol; glycerin**

Classification of Alcohols

Primary alcohol (1°)

- **Primary alcohol (1°) - the carbon atom carrying the -OH group is attached to one other carbon atom**



CH_3CH_2OH

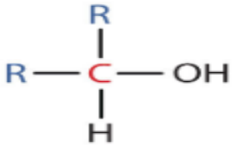
Ethanol (ethyl alcohol)

$CH_3CH_2CH_2OH$

1-Propanol (propyl alcohol)

Secondary alcohol (2°)

- **Secondary alcohol (2°) - the carbon atom carrying the -OH group is attached to two other carbon atoms**

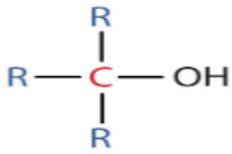


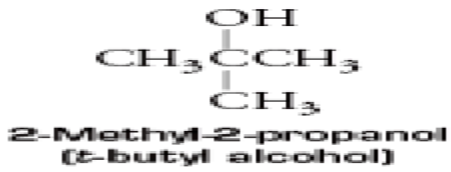
$CH_3\overset{\overset{OH}{|}}{C}HCH_3$

2-Propanol (isopropyl alcohol)

Tertiary alcohol (3°)

- **Tertiary alcohol (3°) - the carbon atom carrying the -OH group is attached to three other carbon atoms**

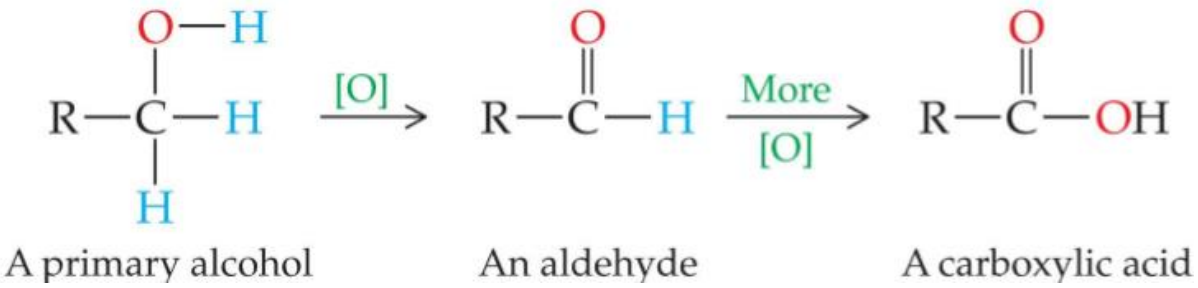




Different kinds of carbonyl compounds are formed, depending on the structure of the starting alcohol and the reaction conditions.

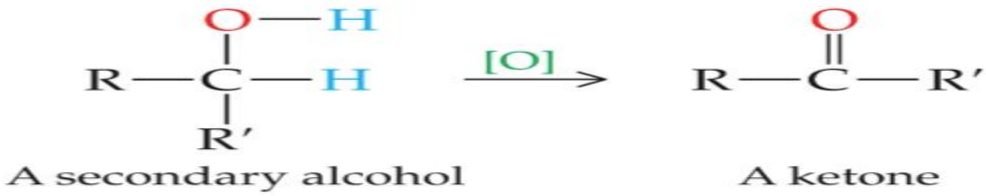
Primary alcohols

- **Primary alcohols are converted either into an aldehyde if carefully controlled conditions are used, or into a carboxylic acid if an excess of oxidant is used.**



Secondary alcohols

- **Secondary alcohols are converted into ketones on treatment with oxidizing agent**



Tertiary alcohols

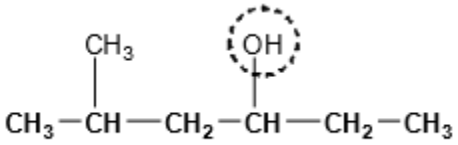
- **Tertiary alcohols don't react with oxidizing agents because they do not have a hydrogen on the carbon atom to which the OH group is attached**

Naming Alcohols

- **When the IUPAC rules are used to name an alcohol, the parent (the longest continuous carbon chain carrying the OH group) is numbered from the end nearer the -OH and named by dropping the "e" ending on the name of the corresponding hydrocarbon by adding "ol."**
- **When a parent chain contains more than two carbon atoms, the position of the -OH group must be specified with a number.**
- **Any alkyl groups attached to the parent chain are identified by name, position, and number of appearances**

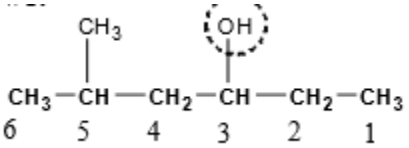
Naming Alcohols

STEP 1: Name the parent compound. Find the longest chain that has the hydroxyl substituent attached (replace the -e ending with –ol).



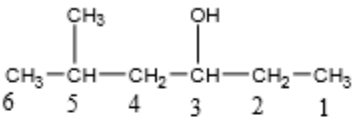
Name as a *hexanol*
a six-carbon chain
containing a hydroxyl group.

STEP 2: Number the carbon atoms in the main chain. Begin at the end nearer the hydroxyl group, ignoring the location of other substituents. In a cyclic alcohol, the carbon that bears the –OH group is #1.

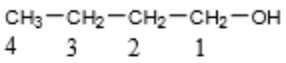


Begin numbering at this end because is closer to the -OH group.

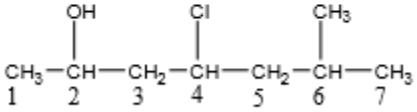
STEP 3: Write the name, placing the number that locates the hydroxyl group immediately before the parent compound name. In a cyclic alcohol the number "1" for the location of the –OH group is not needed.



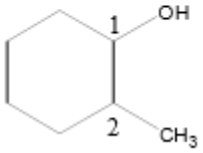
5-methyl-3-hexanol



1-butanol

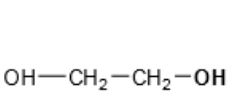


4-chloro-6-methyl-2-heptanol

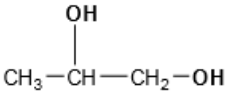


2-methylcyclohexanol

Dialcohols, or diols, are often called glycols

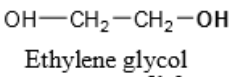


Ethylene glycol
(1,2-ethane**diol**)

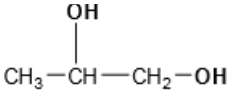


Propylene glycol
(1,2-propane**diol**)

When the molecule has more than one alcohol group, the complete alkane name is used as you can see here (names in parenthesis).



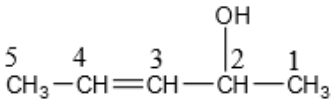
Ethylene glycol
(1,2-ethane**diol**)



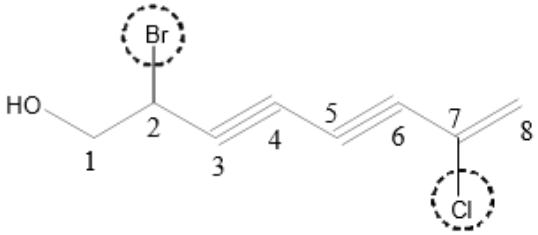
Propylene glycol
(1,2-propane**diol**)

When the molecule has more than one alcohol group, the complete alkane name is used as you can see here (names in parenthesis).

- Unsaturated alcohols Alcohol (hydroxyl) group takes precedence. Assign that carbon the lowest number.



pent-4-en-2-ol
(4-penten-2-ol)



2-bromo-7-chloroocta-7-en-3,5-diyn-1-ol

Properties of Alcohols

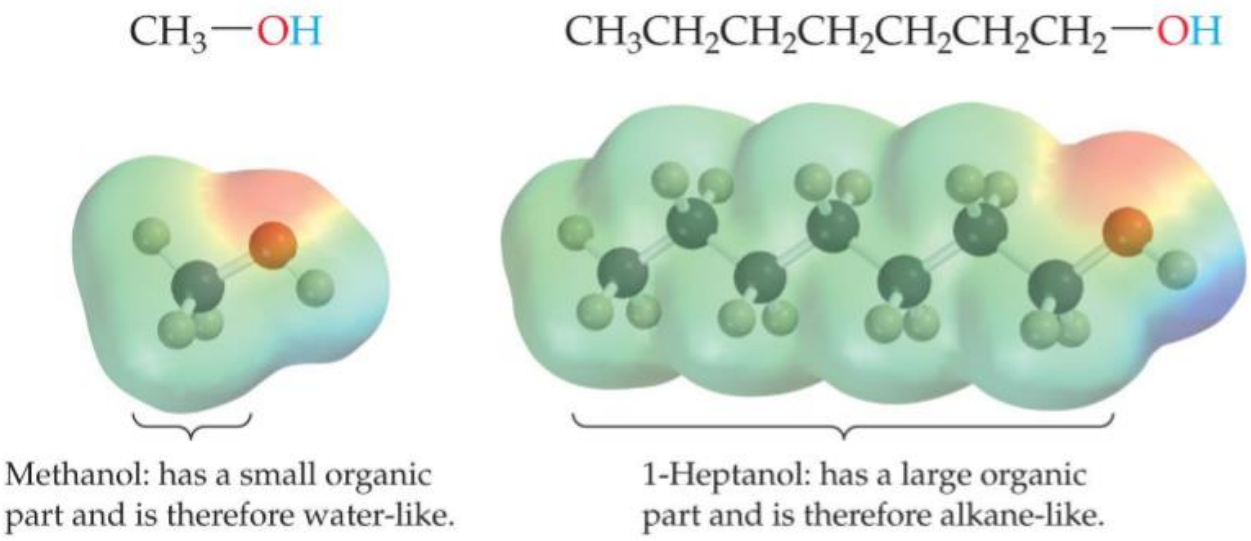
- Compared to hydrocarbons with a similar molecular weight, alcohols have relatively high boiling points.

Properties of Alcohols

Formula	IUPAC Name	Common Name	Boiling Point (°C)	Water Solubility (g/100 mL)
Alcohols				
CH_3OH	Methanol	Methyl alcohol	65.0	Miscible[a]
CH_3CH_2OH	Ethanol	Ethyl alcohol	78.5	Miscible
$CH_3CH_2CH_2OH$	1-Propanol	Propyl alcohol	97.4	Miscible
$CH_3CH_2CH_2CH_2OH$	1-Butanol	Butyl alcohol	117.3	8.0
$CH_3CH_2CH_2CH_2CH_2OH$	1-Pentanol	Pentyl alcohol	138	2.2
Alkanes				
CH_3CH_3	Ethane		−89	~0
$CH_3CH_2CH_3$	Propane		−42	~0
$CH_3CH_2CH_2CH_3$	Butane		0	~0
$CH_3CH_2CH_2CH_2CH_3$	Pentane		36	~0

[a]Can be mixed in all proportions.

- Alcohols with a small hydrocarbon part are H2O soluble. Alcohols with a large hydrocarbon part are insoluble in H2O



Methanol: has a small organic part and is therefore water-like.

1-Heptanol: has a large organic part and is therefore alkane-like.

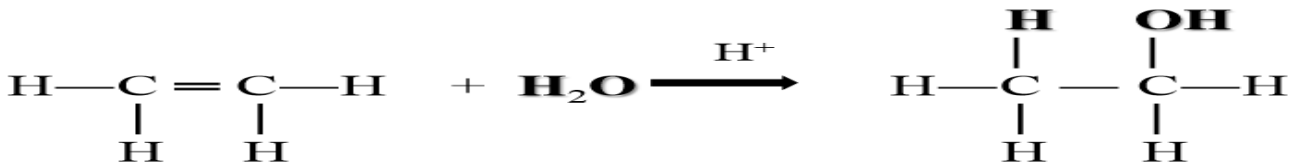
- London dispersion forces can increase the boiling point of alcohols as the nonpolar portion of the molecule grows larger:

Formula	IUPAC Name	Common Name	Boiling Point (°C)	Water Solubility (g/100 mL)
Alcohols				
CH_3OH	Methanol	Methyl alcohol	65.0	Miscible[a]
CH_3CH_2OH	Ethanol	Ethyl alcohol	78.5	Miscible
$CH_3CH_2CH_2OH$	1-Propanol	Propyl alcohol	97.4	Miscible
$CH_3CH_2CH_2CH_2OH$	1-Butanol	Butyl alcohol	117.3	8.0
$CH_3CH_2CH_2CH_2CH_2OH$	1-Pentanol	Pentyl alcohol	138	2.2

Preparation of Alcohols

1. Hydration of Alkenes

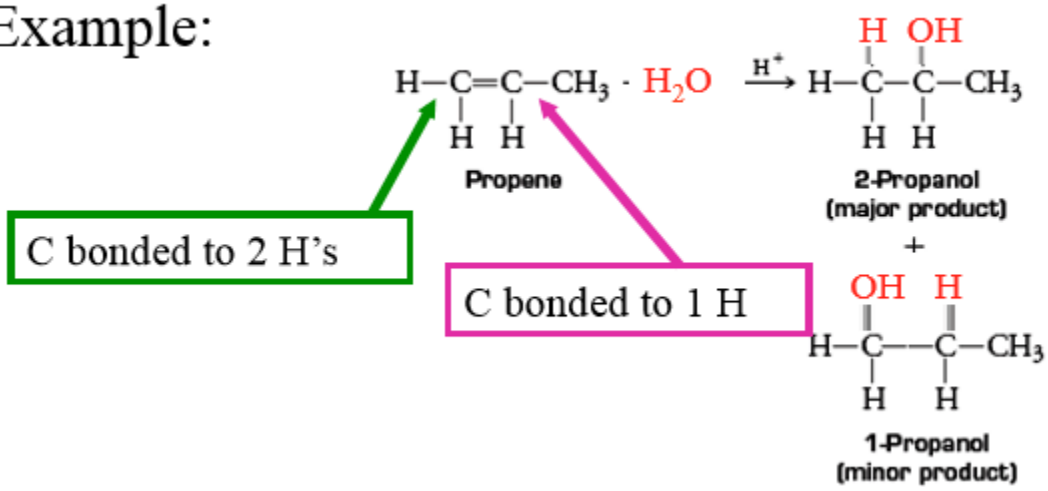
- In a hydration reaction, water is added to a double bond.



Hydration of Alkenes (Markovnikov's Rule)

- In the preparation of alcohols from asymmetric alkenes, it is possible to form two different alcohols.

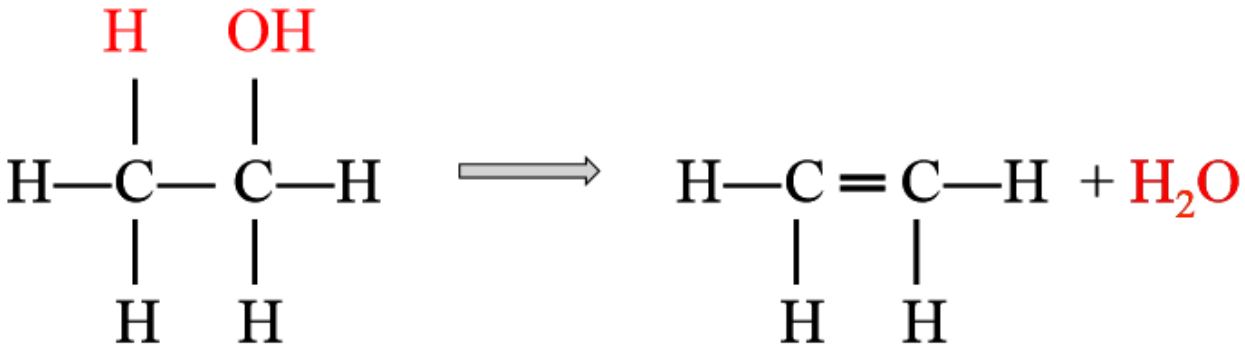
Example:



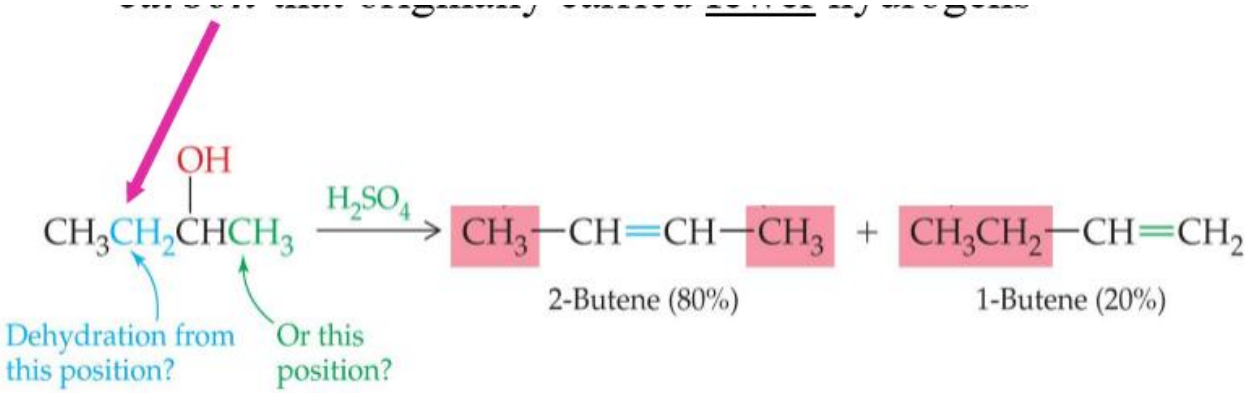
- Markovnikov's rule says that, to predict the major product: a hydrogen is added to the double-bonded carbon that originally carried the most hydrogens.

2,Dehydration of Alcohols

- **Dehydration: Alcohols undergo dehydration upon treatment with a strong acid catalyst to form alkenes. (Chapter 6)**
- **The –OH group is lost from one carbon and an H is lost from an adjacent carbon to yield an alkene product**

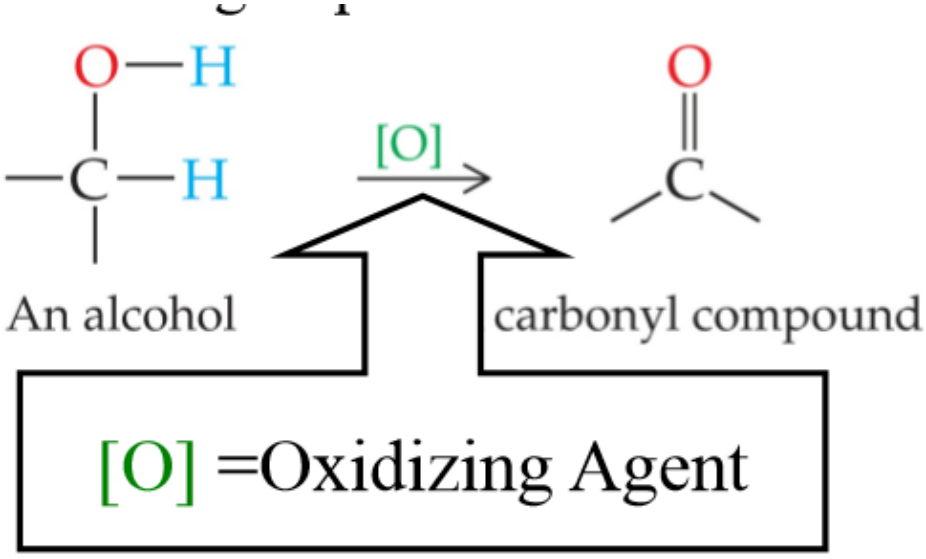


- When more than one alkene can result from dehydration of an alcohol, a mixture of products is usually formed.
- The double bond forms better with the adjacent carbon that originally carried fewer hydrogens



Oxidation of Alcohols

- **In the oxidation of an alcohol, two hydrogen atoms are removed from the alcohol: one hydrogen comes from the OH group and the other comes from the carbon bonded to the OH group**

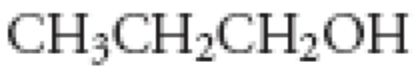


- Many different oxidizing agents, such as potassium permanganate (KMnO4), potassium dichromate (K2Cr2O7) can be used

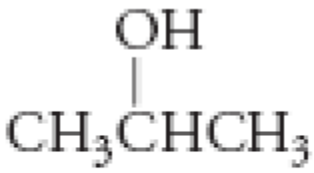
Naming Alcohols: Examples



Ethanol
(ethyl alcohol)

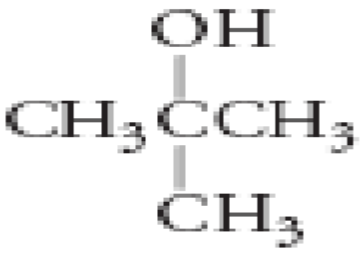


1-Propanol
(propyl alcohol)



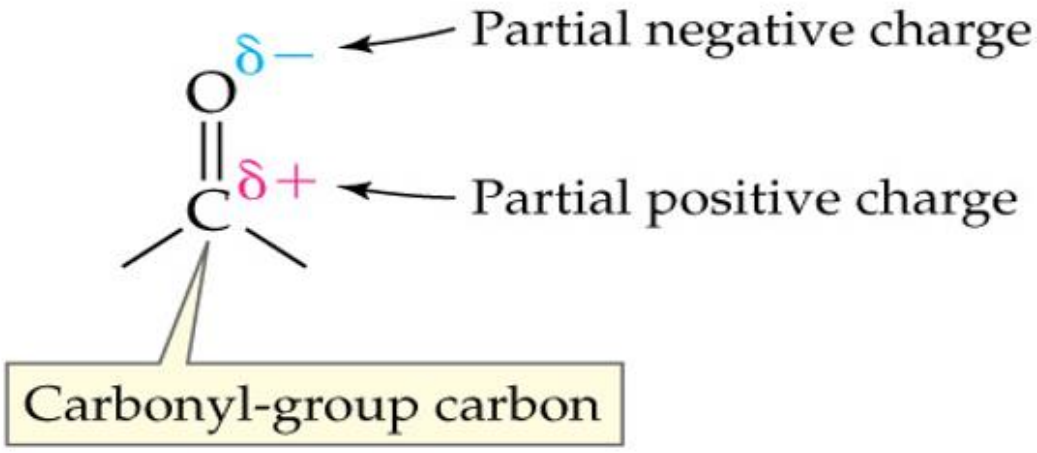
2-Propanol
(isopropyl alcohol)

Name this molecule:



2-methyl-2-propanol

The Carbonyl Group Carbonyl compound:
➢ **Any compound that contains a carbonyl group (C=O). Carbonyl groups are strongly polarized, with a partial positive charge on carbon and partial negative charge on oxygen**



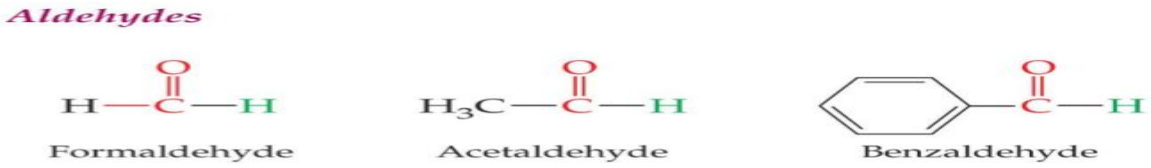
➢ The Carbonyl Functional Groups Carbonyl compounds include: aldehydes and ketones, carboxylic acids, esters, and amides

FAMILY NAME	STRUCTURE	EXAMPLE	
Aldehyde	R—C(=O)—H	H_3C—C(=O)—H	Acetaldehyde
Ketone	R—C(=O)—R′	H_3C—C(=O)—CH_3	Acetone
Carboxylic acid	R—C(=O)—O—H	H_3C—C(=O)—O—H	Acetic acid
Ester	R—C(=O)—O—R′	H_3C—C(=O)—O—CH_3	Methyl acetate
Amide	R—C(=O)—N	H_3C—C(=O)—NH_2	Acetamide

Aldehyde and Ketones



- Naming Aldehydes & Ketones The simplest aldehydes are known by their common names, formaldehyde, acetaldehyde, benzaldehyde, and so on.



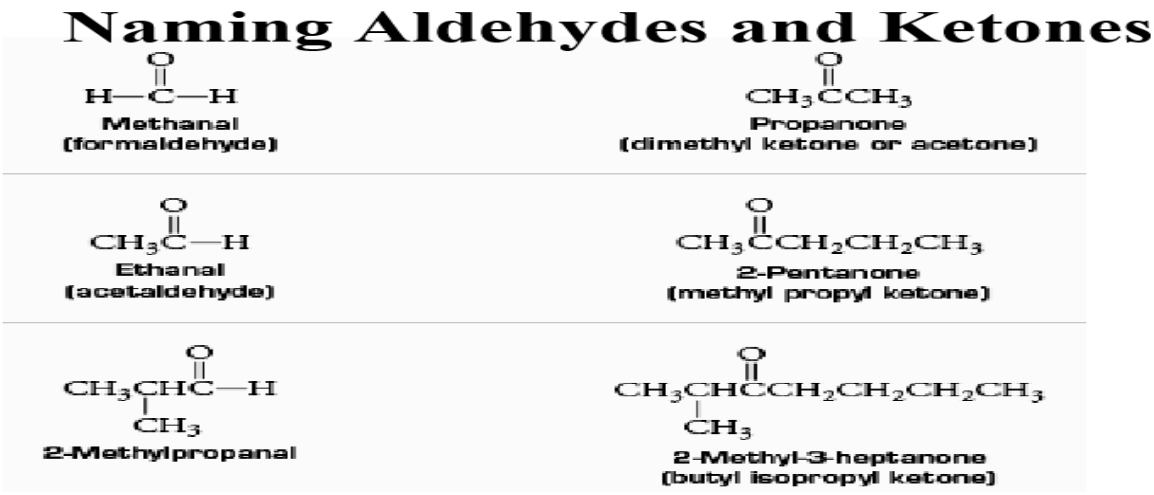
Naming Aldehydes & Ketones

- Some ketones are best known by their common names that give the names of the two alkyl groups bonded to the carbonyl group followed by the word ketone.

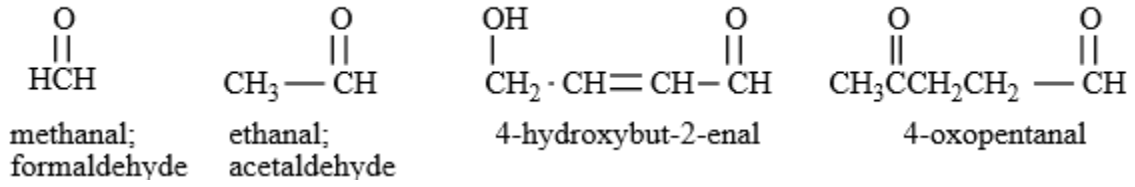


Naming Aldehydes and Ketones •

- **When naming aldehydes and ketones according to the IUPAC rules, the carbonyl (C=O) must be part of the parent chain, which is numbered from the end nearer this group.**
- **Since the carbonyl carbon atom of an aldehyde is always in position number 1, its position is not specified in the name.**
- **For ketones, however, the position of the carbonyl carbon is given, unless the molecule is small enough that there is no question as to carbonyl placement (propanone).**
- **Parent chains are named by dropping the final "e" from the name of the corresponding hydrocarbon and adding "al" for aldehydes or "one" for ketones.**

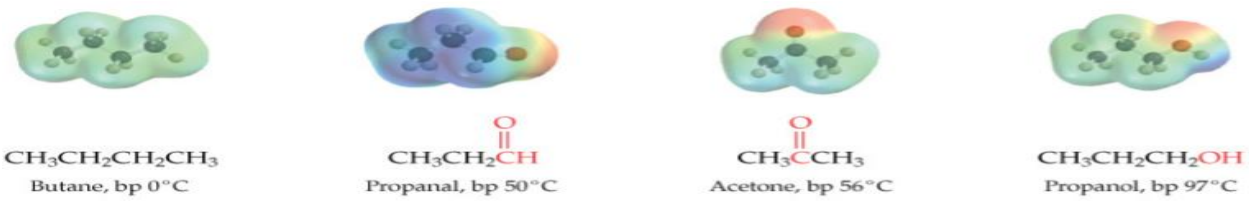


4. Aldehydes: prefix: oxo-, or formyl- (O=CH-); suffix: -al (abbreviation: —CHO). An aldehyde can only be on carbon 1, so the "1" is generally omitted from the name.



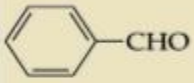
Properties of Aldehydes & Ketones

- **The polarity of carbonyl group makes aldehydes and ketones moderately polar compounds. •**
- **Aldehydes and ketones don't form hydrogen bonds to each other, however, they form hydrogen bond with water using the electron lone pairs on oxygen**
- **Aldehydes and ketones have lower boiling points compared to alcohols of similar size.**



Properties of Aldehydes & Ketones

Aldehydes and ketones with fewer than five carbons are soluble in water

STRUCTURE	NAME	BOILING POINT (°C)	WATER SOLUBILITY (g/100 mL H_2O)
HCHO	Formaldehyde	−21	55
CH_3CHO	Acetaldehyde	21	Soluble
CH_3CH_2CHO	Propanal	49	16
$CH_3CH_2CH_2CHO$	Butanal	76	7
$CH_3CH_2CH_2CH_2CHO$	Pentanal	103	1
	Benzaldehyde	178	0.3
CH_3COCH_3	Acetone	56	Soluble
$CH_3CH_2COCH_3$	2-Butanone	80	26
$CH_3CH_2CH_2COCH_3$	2-Pentanone	102	6
	Cyclohexanone	156	2

Some Common Aldehydes & Ketones •

Formaldehyde, HCHO

- **, is toxic but useful. It kills viruses, fungi, and bacteria, and is used to disinfect and sterilize equipment.**
- **Formaldehyde will polymerize with other compounds, being converted into linking -CH2- groups.**
- **The polymers are used to make plastics and adhesive and for binding plywood. Fresh polymers may outgas formaldehyde vapor.**

Acetaldehyde, CH3CHO,

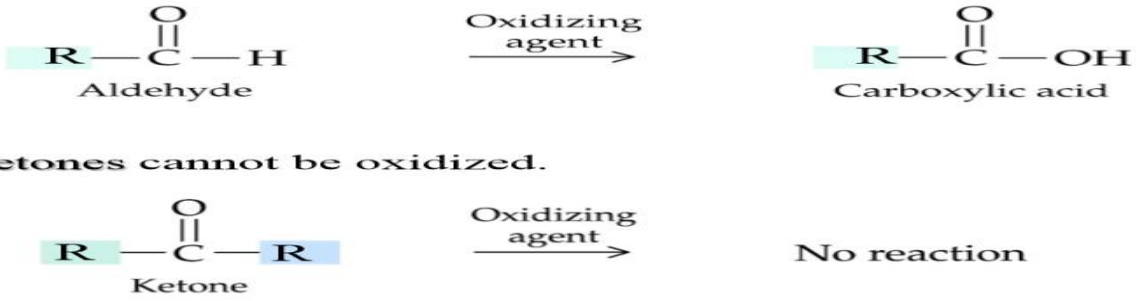
- **is sweet smelling but narcotic.**
- **It is present in ripe fruits, especially in apples, and is a metabolite of ethanol. It is less toxic than formaldehyde**

Acetone, CH3COCH3,

- **is a super solvent; it is one of the most widely used solvents.**
- **It can dissolve most organic compounds and is also miscible with water.**
- **Casual exposure to acetone poses no health risk.**
- **Acetone is highly volatile and is also highly flammable.**

Oxidation of Aldehydes and Ketones •

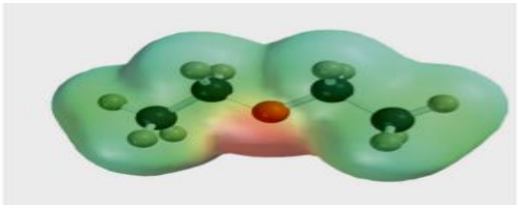
- Aldehydes can be further oxidized to carboxylic acids.



Ethers • An ether is a compound that has an oxygen bonded to two organic groups, R-O-R.

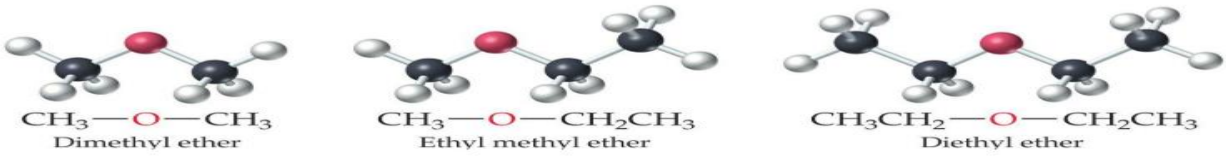
$CH_3CH_2OCH_2CH_3$

Diethyl ether

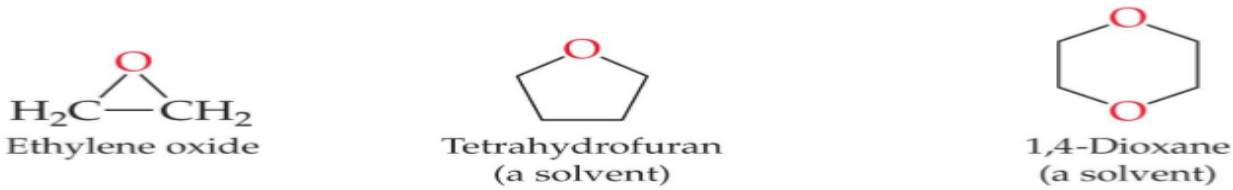


Naming Ethers

Ethers are named by identifying the two organic groups and adding the word "ether".



Compounds containing oxygen in a ring are classified as cyclic ethers and are often given common names



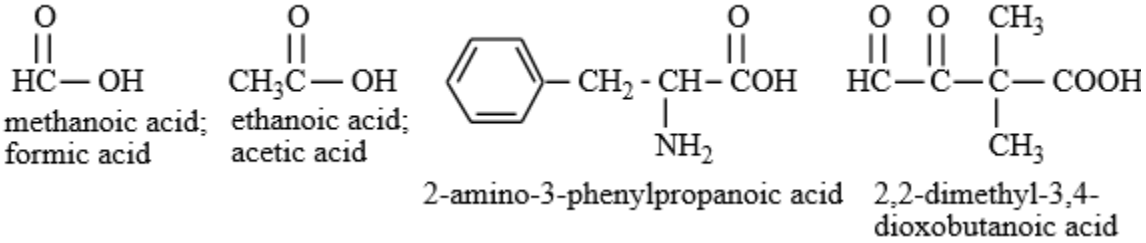
Properties of Ethers

Ether

- **Ethers do not hydrogen bond to one another. As a result they have lower boiling point than alcohols. •**
- **The ether oxygen can form hydrogen bonds with water, causing low molecular weight ethers to be water soluble.**
- **Ethers with large organic groups are water insoluble**

.

Carboxylic Acids: prefix: carboxy-; suffix: -oic acid (abbreviation: —COOH). A carboxylic acid can only be on carbon 1, so the "1" is generally omitted from the name.



E. Naming Carboxylic Acid Derivatives

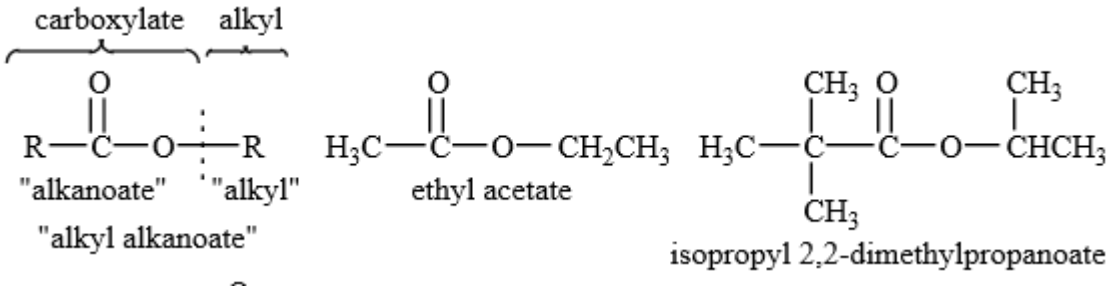
- **The six common groups derived from carboxylic acids are salts, anhydrides, esters, acyl halides, amides, and nitriles. Salts and esters are most important.**

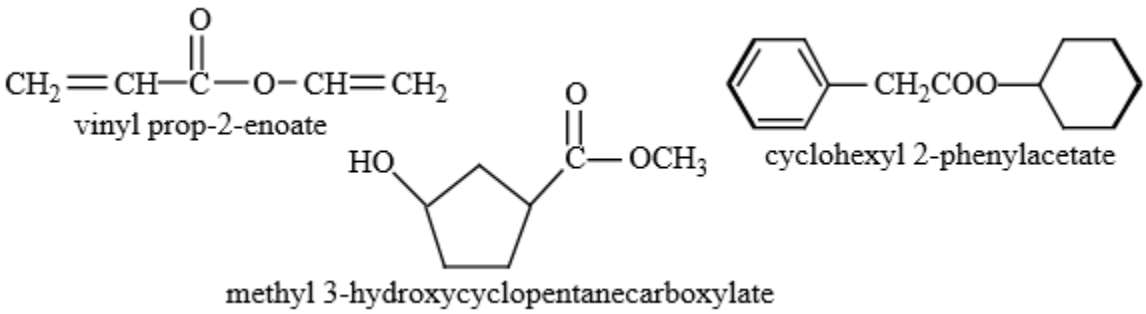
1. Salts of Carboxylic Acids

- **Salts are named with cation first, followed by the anion name of the carboxylic acid, where "ic acid" is replaced by "ate" :acetic acid becomes acetate butanoic acid becomes butanoate cyclohexanecarboxylic acid becomes cyclohexanecarboxylate**

2. Esters

- **Esters are named as "organic salts" that is, the alkyl name comes first, followed by the name of the carboxylate anion. (common abbreviation: —COOR**

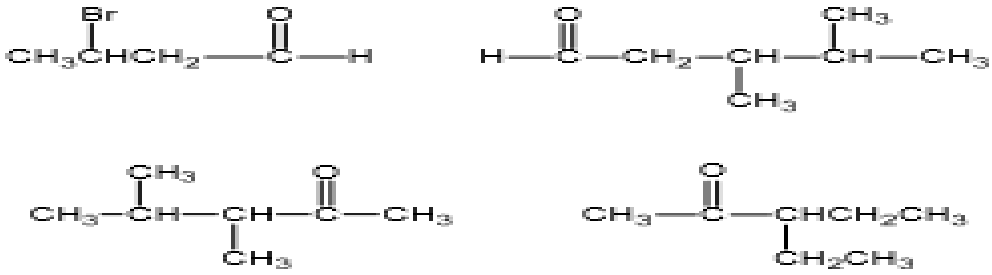


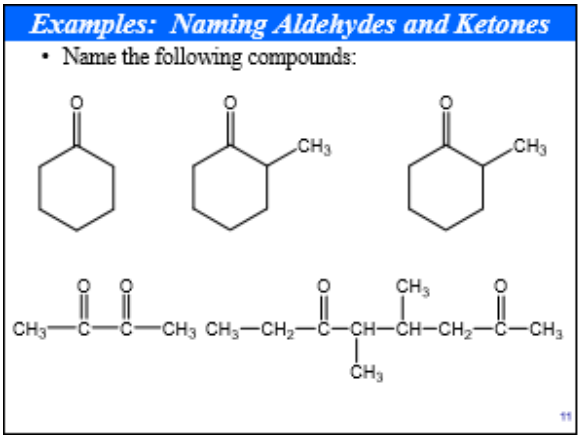


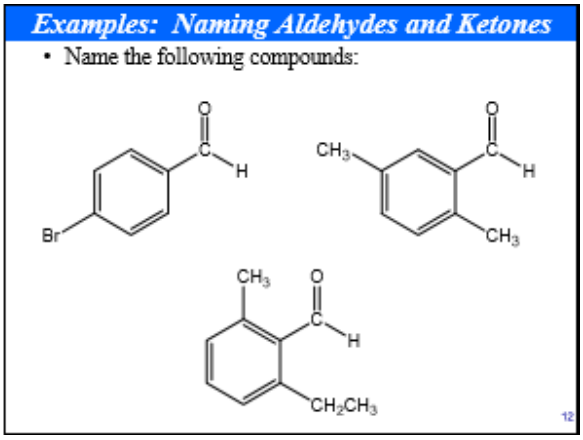
Exercise

1.

- Name the following compounds:







Examples: Naming Aldehydes and Ketones

- Draw structural formulas for the following molecules:
  - 3-ethyl-2-pentanone
  - 2,4,6-trimethylheptanal
  - 3-ethylcyclopentanone

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Examples: Naming Aldehydes and Ketones

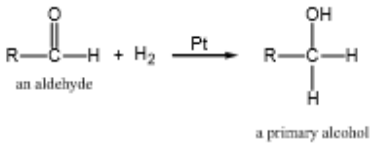
- Draw structural formulas for the following molecules:
  - 4-chloro-2-phenylpentanal
  - para-nitrobenzaldehyde
  - 3-ethyl-2-butanone (what's wrong with this name?)

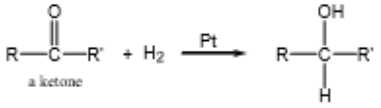
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Summary

Hydrogenation of Aldehydes and Ketones

- **Hydrogenation** of aldehydes and ketones with hydrogen gas and a platinum catalyst produces alcohols:

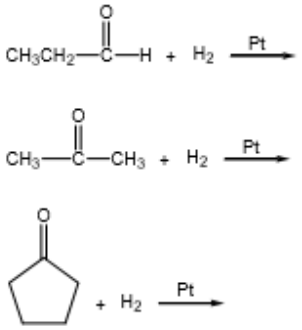




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Examples: Hydrogenation Reactions

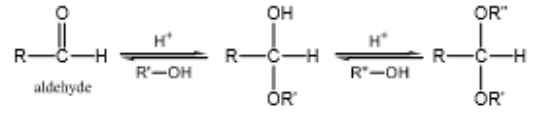
- Complete the following reactions:

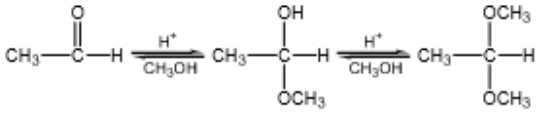


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Addition of Alcohols to Aldehydes

- Aldehydes react with alcohols first to form **hemiacetals**, which then react with excess alcohol to produce **acetals**.

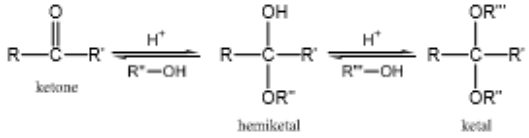


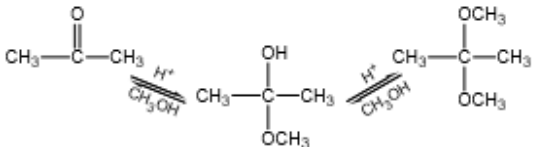


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Addition of Alcohols to Ketones

- Ketones react with alcohols first to form **hemiketals**, which then react with excess alcohol to produce **ketals**.





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Reactions of Aldehydes and Ketones

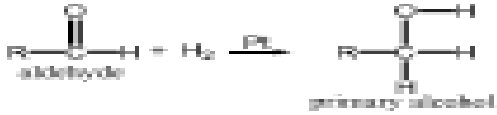
1. **Oxidation of Aldehydes to give Carboxylic Acids**



2. **Oxidation of Ketones — No Reaction**



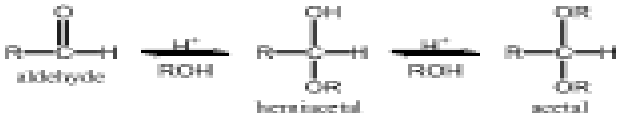
3. **Hydrogenation of Aldehydes to give Primary Alcohols**



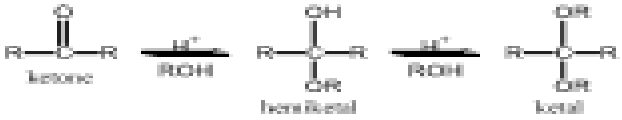
4. **Hydrogenation of Ketones to give Secondary Alcohols**



5. **Addition of an Alcohol to an Aldehyde to form an Acetal**



6. **Addition of an Alcohol to a Ketone to form a Ketal**



7. **Hydrolysis of an Acetal to give an Aldehyde**



8. **Hydrolysis of a Ketal to give a Ketone**



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