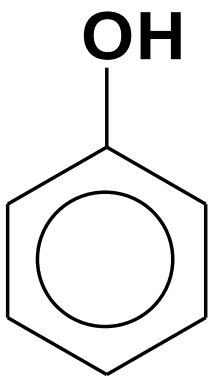
Alcohols, Phenols and Ethers

Naming, Physical Properties and Reactions

Compounds with Single Bonded Oxygen Atoms

Alcohols **-OH (hydroxyl)** **CH_3-OH**

Phenols – hydroxyl and benzene ring



Ethers **-O-** **CH_3-O-CH_3**

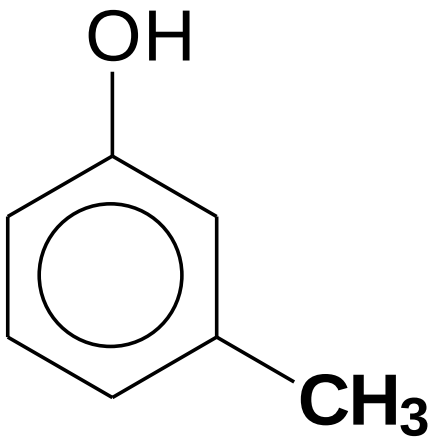
Learning Check

Classify each as an alcohol (1), phenol (2), or an ether (3):

A. _____ CH_3CH_2-O-CH_3

C. _____ CH_3CH_2OH

B. _____



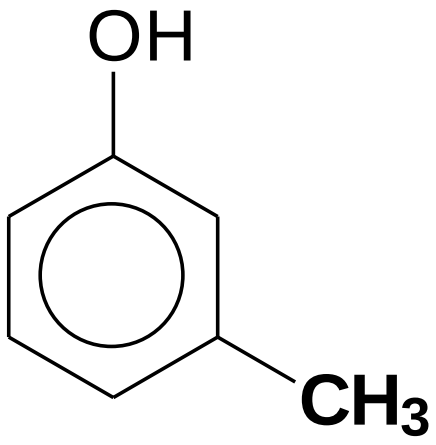
Solution

Classify each as an alcohol (1), phenol (2), or an ether (3):

A. 3 CH_3CH_2-O-CH_3

C. 1 CH_3CH_2OH

B. 2



Naming Alcohols

- A carbon compound that contains an -OH (hydroxyl) group
- In the IUPAC name, the -e in alkane name is replaced with -ol.
- If there is more than one hydroxyl group, then the name's ending is –diol, triol, etc.

CH_4 methane

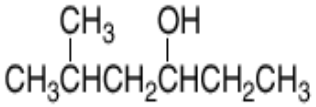
CH_3OH methanol

CH_3CH_3 ethane

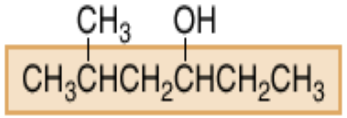
CH_3CH_2OH ethanol

How To — Name an Alcohol Using the IUPAC System

Example Give the IUPAC name of the following alcohol:



Step [1] Find the longest carbon chain containing the carbon bonded to the OH group.



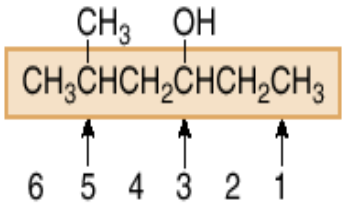
6 C's in the longest chain

6 C's → hexane → hexanol

- Change the ***-e*** ending of the parent alkane to the suffix ***-ol.***

Step [2] Number the carbon chain to give the OH group the lower number, and apply all other rules of nomenclature.

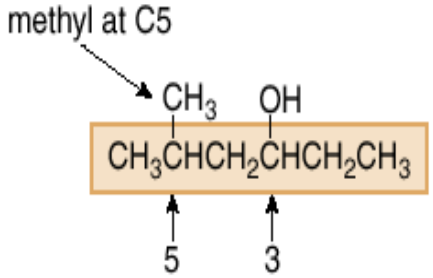
a. **Number** the chain.



- Number the chain to put the OH group at C3, not C4.

3-hexanol

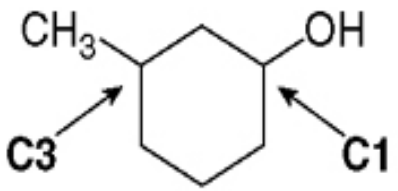
b. **Name** and **number** the substituents.



Answer: 5-methyl-3-hexanol

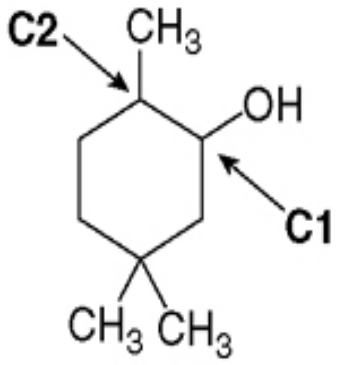
- When an OH group is bonded to a ring, the ring is numbered beginning with the OH group.
- Because the functional group must be at C1, the 1 is usually omitted from the name.
- The ring is then numbered in a clockwise or counterclockwise fashion to give the next substituent/branch the lowest number.

Examples: Naming cyclic alcohols



3-methylcyclohexanol

[The OH group is at C1; the second substituent (CH_3) gets the lower number.]



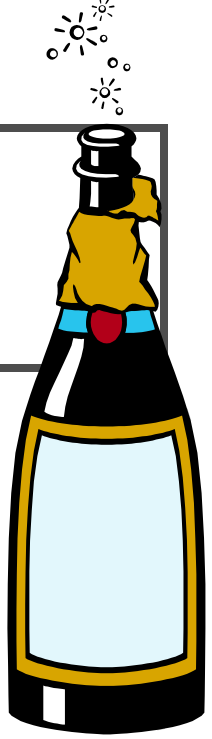
2,5,5-trimethylcyclohexanol

[The OH group is at C1; the second substituent (CH_3) gets the lower number.]

Ethanol CH_3CH_2OH

- Acts as a depressant
- Kills or disables more people than other drug
- 12-15 mg/dL ethanol metabolized by a social drinkers in one hour
- 30 mg/dL ethanol metabolized by an alcoholic in one hour.
- Gasahol: 10% ethanol in gasoline
- Toxic dose: 200 mL ethanol, 100 mL methanol

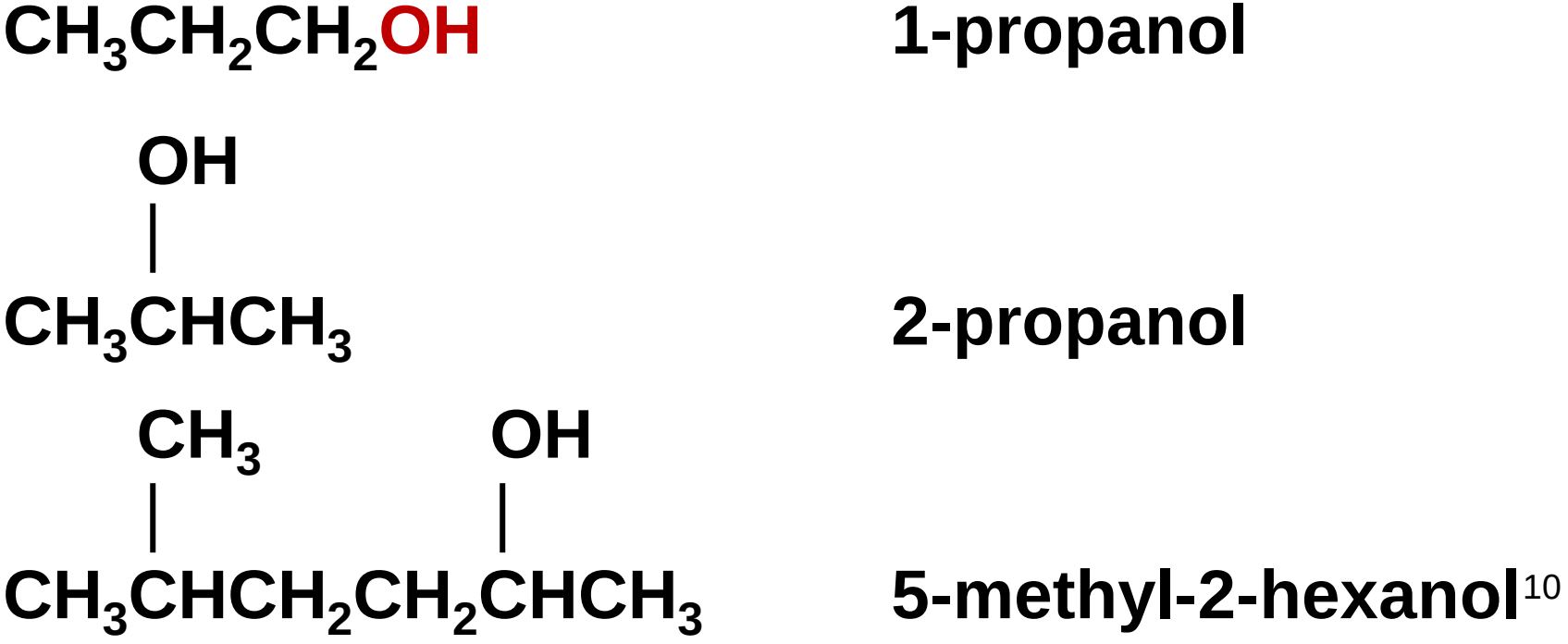
Alcohol in Some Products



% Ethanol	Product
50%	Whiskey, rum, brandy
40%	Flavoring extracts
15-25%	Listerine, Nyquil, Scope
12%	Wine, Dristan, Cepacol
3-9%	Beer, Lavoris

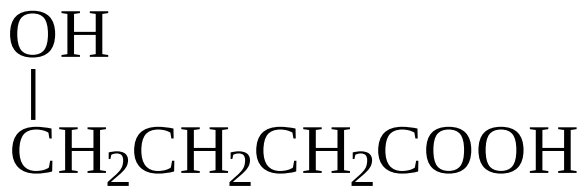
More Names of Alcohols

- **IUPAC names for longer chains (more than 2 carbons) number the chain from the end nearest the -OH group and identify the location of the –OH group(s) with a number.**



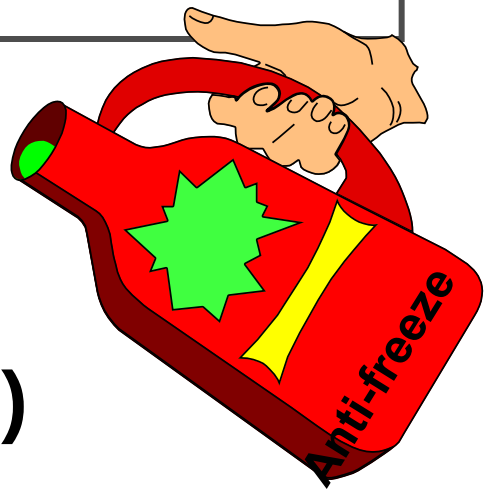
Alternative method of naming alcohols

- Name the hydroxyl group as a branch and call it “hydroxy”
- List it alphabetically in the name



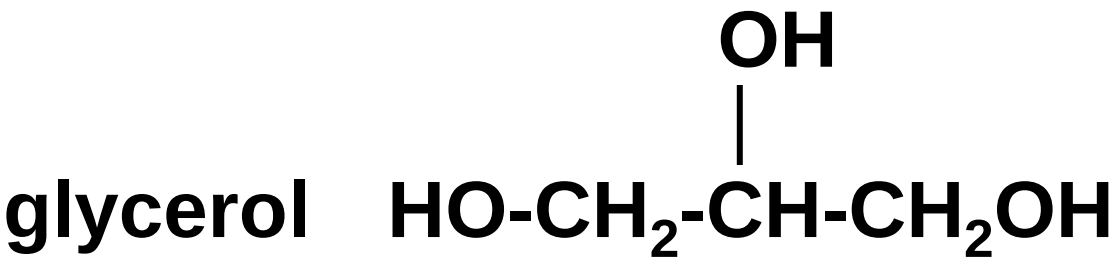
4-hydroxybutanoic acid

Some Typical Alcohols



2-propanol (isopropyl alcohol)

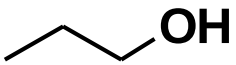
1,2-ethanediol (ethylene glycol)



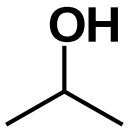
1,2,3-propanetriol

Nomenclature of Alcohols

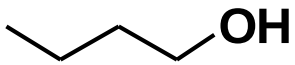
- Examples



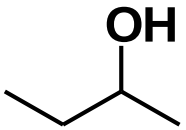
1-Propanol
(Propyl alcohol)



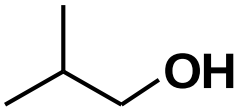
2-Propanol
(Isopropyl alcohol)



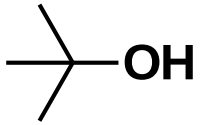
1-Butanol
(Butyl alcohol)



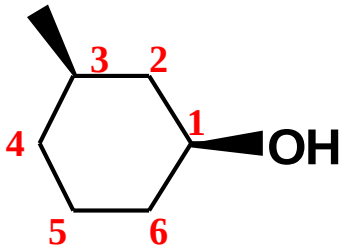
2-Butanol
(*sec*-Butyl alcohol)



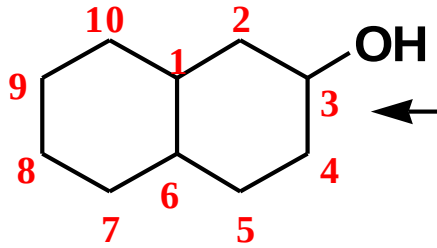
2-Methyl-1-propanol
(Isobutyl alcohol)



2-Methyl-2-propanol
(*tert*-Butyl alcohol)



***cis*-3-Methylcyclohexanol**



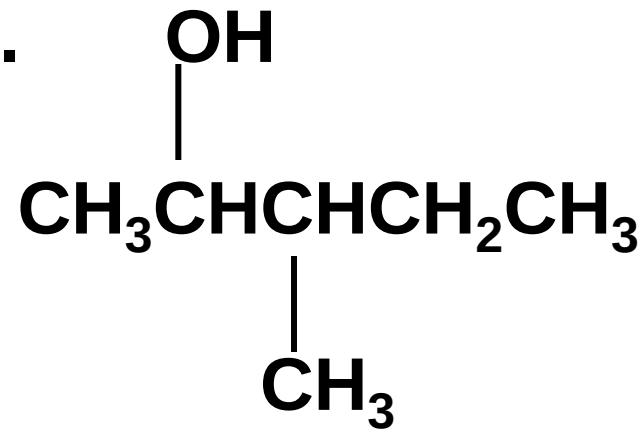
Bicyclo[4.4.0]decan-3-ol

Numbering of the bicyclic ring takes precedence over the location of -OH

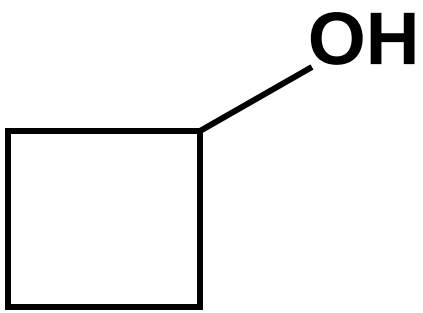
Learning Check

Name the following alcohols:

A.

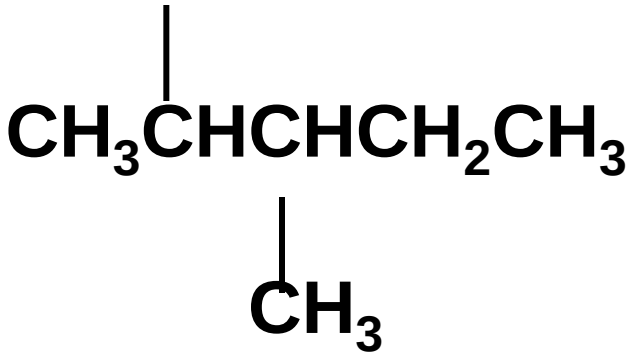


B.

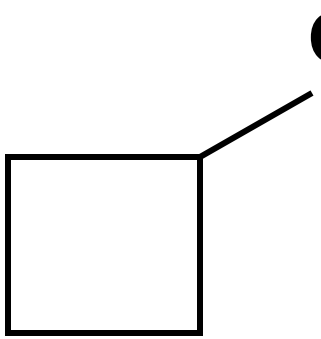


Solution

Name the following alcohols:

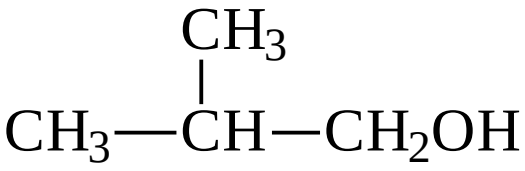
A. 

3-methyl-2-pentanol

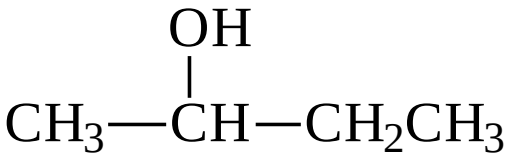
B. 

cyclobutanol

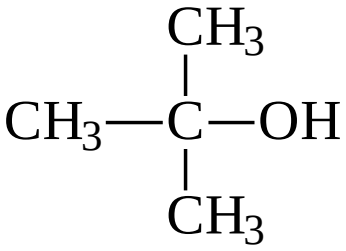
Name these:



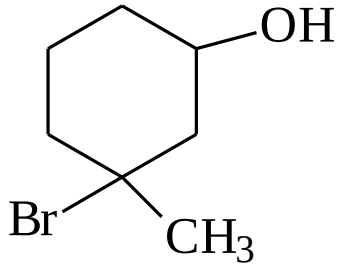
2-methyl-1-propanol



2-butanol

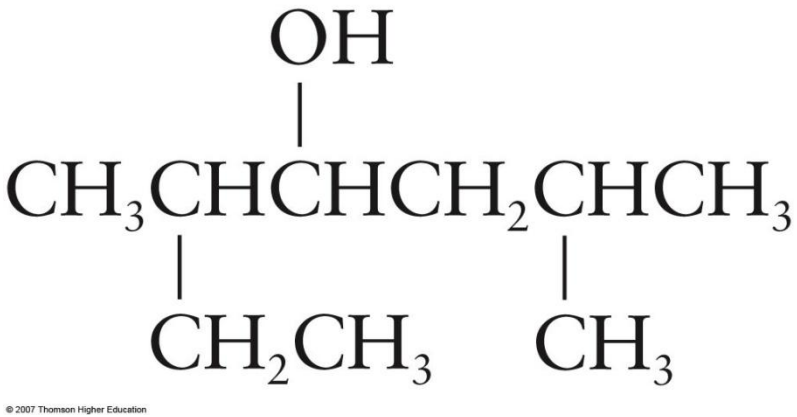


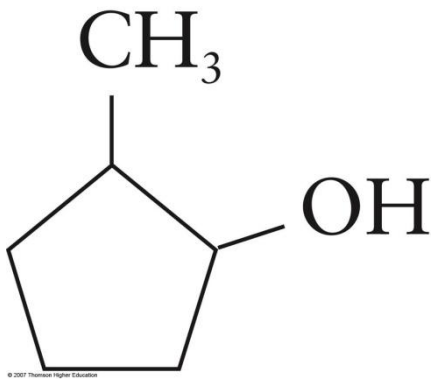
2-methyl-2-propanol



3-bromo-3-methylcyclohexanol

More practice





2, 5–dimethyl-4-heptanol

2-methylcyclopentanol

Physical Properties of Alcohols

1. **Alcohols are polar molecules (because of O-H and C-O which are polar bonds).**

C-O: (3.5 – 2.5 = 1.0) **O-H : (3.5 – 2.1 = 1.4)**

nonpolar  OH polar

2. **Hydrogen bonding occurs between alcohol molecules.**

3. **Have higher melting and boiling points than Alkanes, Alkenes, and Alkynes due to polar bonds (hydrogen bonding).**

4. **Molecular weight ↑ : London dispersion forces ↑ : bp ↑**

5. **More soluble in water than hydrocarbons (Molecular weight ↑ : solubility ↓). Less than 5 carbons are soluble in water.**

6. **They are weak acids (weaker than Phenol).**

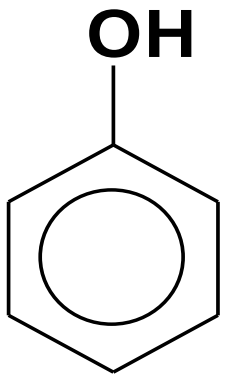
USES: solvents, disinfectants, mouthwash, antifreeze, fuel, hair-spray and other hair products ingredient

Other properties:

Most are poisonous.
Methanol causes blindness or death.
Ethanol causes impairment and/or death if consumed in excess.

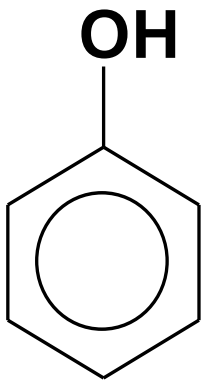
Phenols

- IUPAC name for benzene with a hydroxy group
- Many are used as antiseptics and disinfectants
- Very weak acids

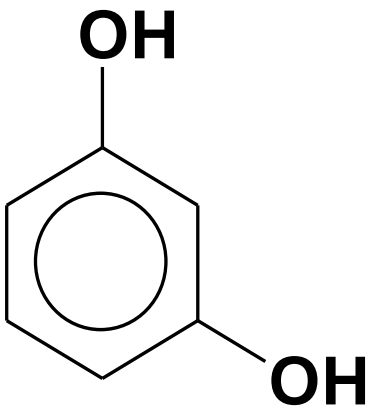


Phenol

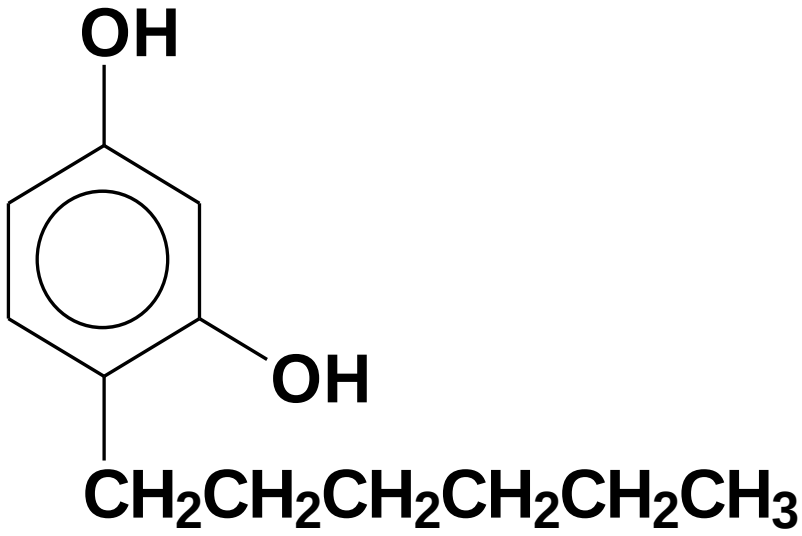
Phenols in Medicine



Phenol

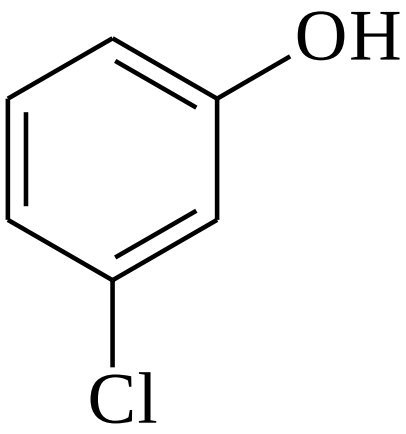


Resorcinol
(antiseptic)

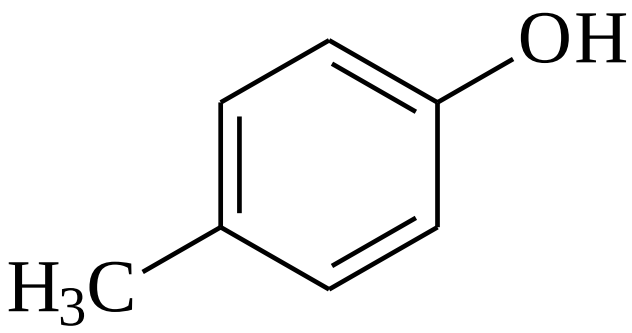


4-Hexylresorcinal
(antiseptic)

Name these phenols:

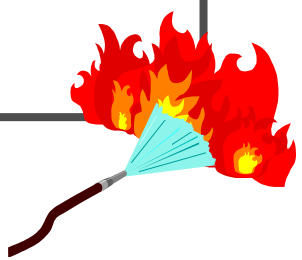


3-chlorophenol



4-methylphenol

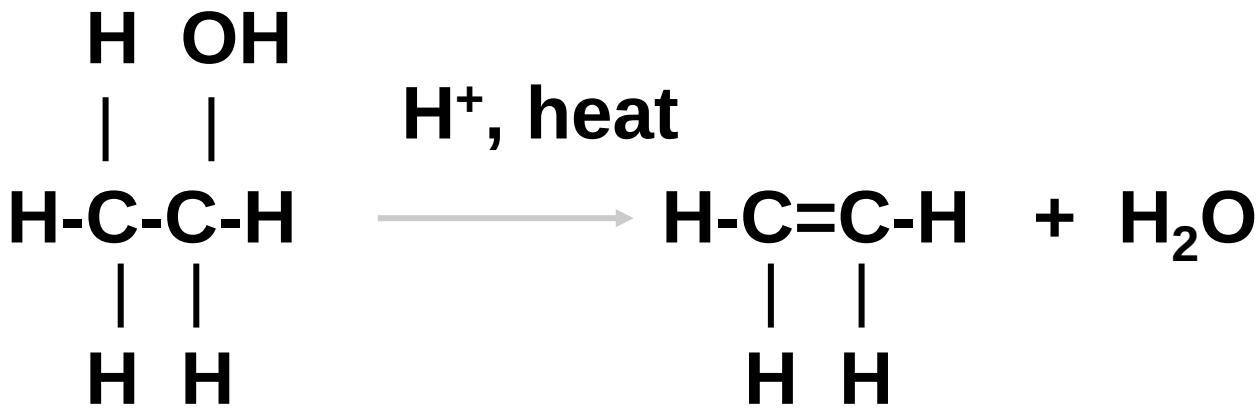
Reactions of Alcohols



Combustion

$$CH_3OH + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Heat}$$

Dehydration



alcohol **alkene**

Esterification

involves carboxylic acids (discuss later)

Ethers

- **Contain an -O- between two carbon groups**
- **Simple ethers are named from -yl names of the attached groups and adding *ether. The proper IUPAC name is the second one listed.***

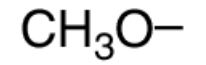
CH_3-O-CH_3 (dimethyl ether) or methoxy methane

CH_3-O-CH_2CH_3 (ethylmethyl ether) or methoxyethane

Naming Ethers

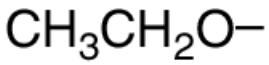
- Name the simpler alkyl group as an alkoxy substituent/branch by changing the –yl ending of the alkyl group to –oxy.
- Name the remaining (longer) alkyl group as an alkane, with the alkoxy group as a substituent/branch bonded to this chain.

Common alkoxy groups



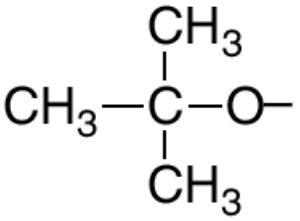
$CH_3O–$

methoxy



$CH_3CH_2O–$

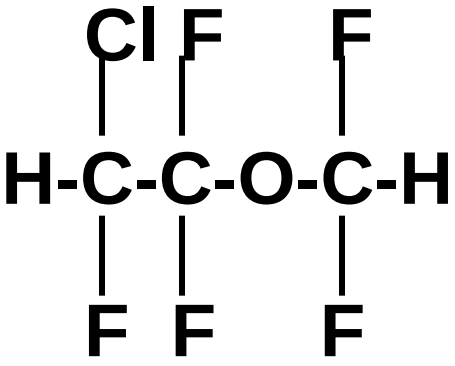
ethoxy



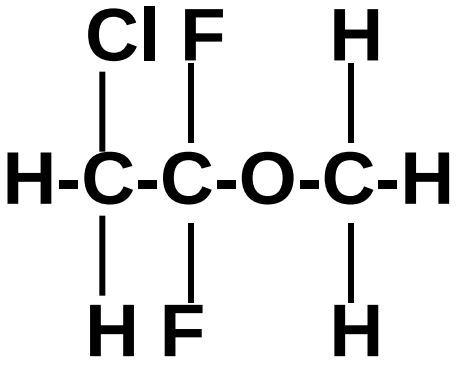
tert-butoxy

Ethers as Anesthetics

- Anesthetics inhibit pain signals to the brain
- CH_3CH_2-O-CH_2CH_3 used for over a century (Morton, 1846)
- Causes nausea and is highly flammable
- 1960s developed nonflammable anesthetics



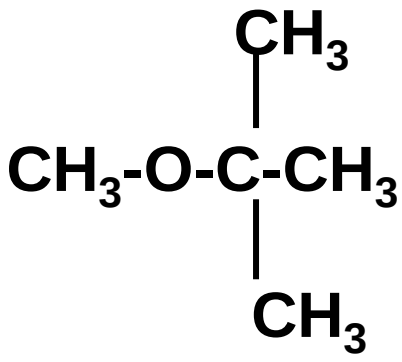
Enflurane (Ethrane)

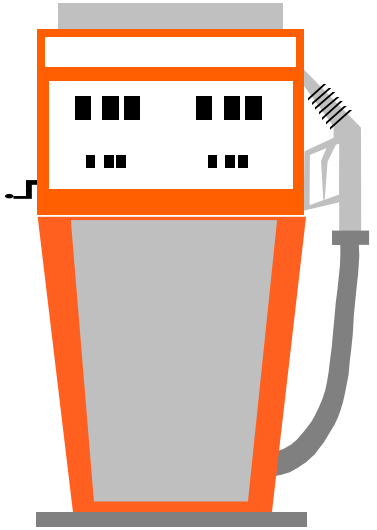


Penthrane

MTBE

- Methyl *tert*-butyl ether





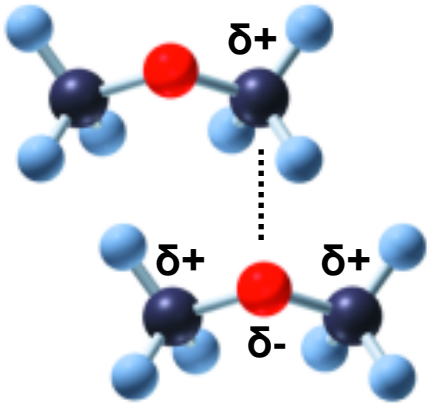
2-methoxy-2-methylpropane (IUPAC name)

- Second in production or organic chemicals
- Additive to improve gasoline performance
- Use in question with discovery of contaminated water supplies

Physical Properties of Ethers

1. They are slightly polar compounds (because of C-O).

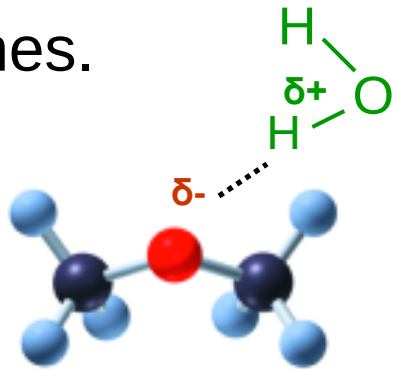
   C-O **(3.5 – 2.5 = 1)**



2. Weak dipole-dipole interactions.

3. Low boiling points**:**
   hydrocarbons < ethers < alcohols.

4. Slightly more soluble in water than other hydrocarbons of similar molecular weight **(H-bond with water).**
   Mix well with other non-polar solvents ex. alkanes.
   (Like dissolves like).



5. Lower ethers, very volatile, highly flammable.

Chemical Properties of Ethers

Ethers are resistant to chemical reactions (inert).

Good solvent for organic reactions.