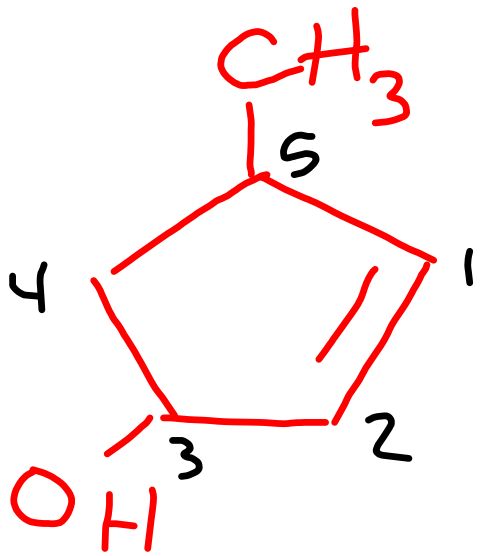
benzene

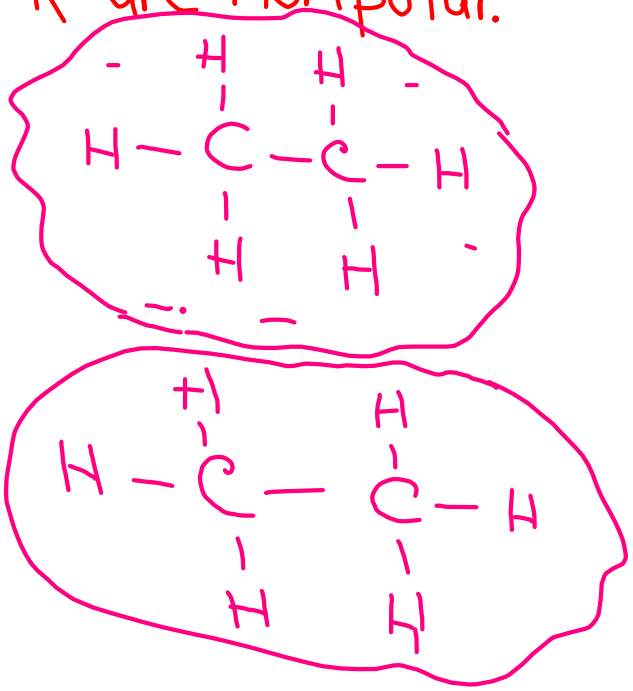
Phenyl



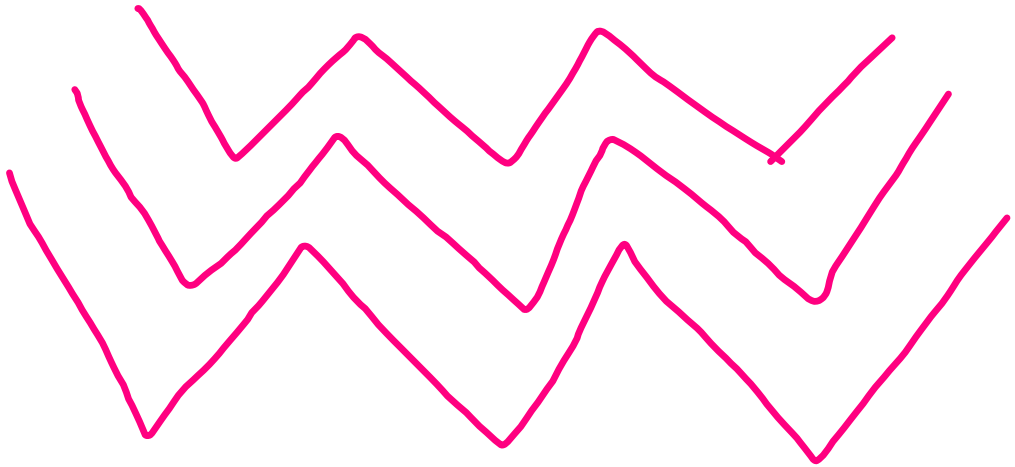
3-hydroxyl-5-methylcyclopentene

Van der Waals - weakest forces between molecules

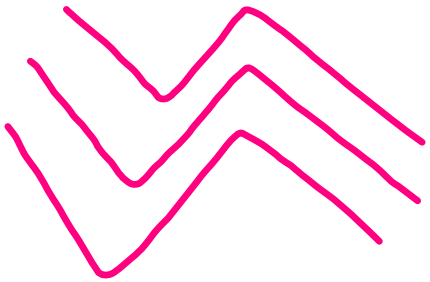
nonpolar all alkyl groups (alkenes, alkynes, and alkanes) R are nonpolar.



b.p.



takes longer



than

R–H

HW
p 502 - 503

13.39, 13.45 not f, 13.47, 13.49,
13.51

Van der Waals' forces include all intermolecular forces that act between electrically neutral molecules. Several special cases occur.

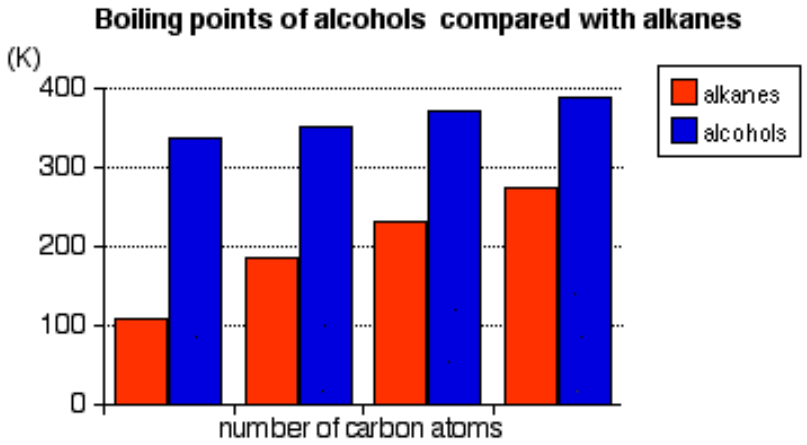
Physical properties of alcohols

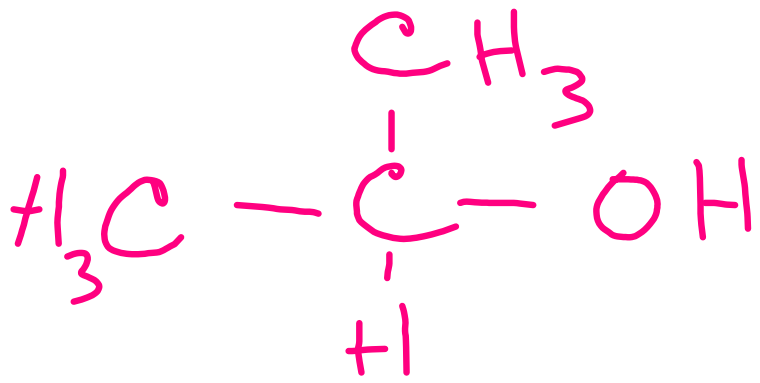
Boiling Points

The chart shows the boiling points of some simple primary alcohols with up to 4 carbon atoms.

CH_3OH	CH_3CH_2OH	$CH_3CH_2CH_2OH$	$CH_3CH_2CH_2CH_2OH$
methanol	ethanol	propan-1-ol	butan-1-ol

They are compared with the equivalent alkane (methane to butane) with the same number of carbon atoms.

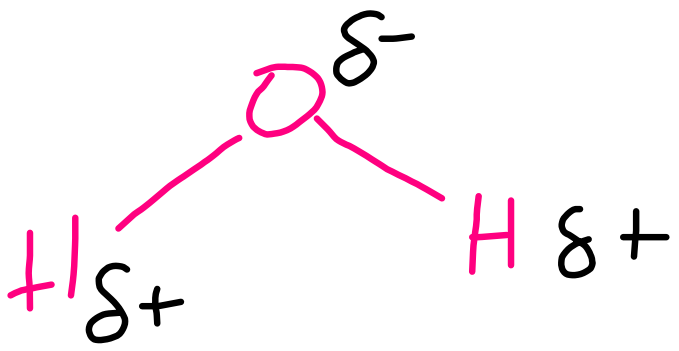


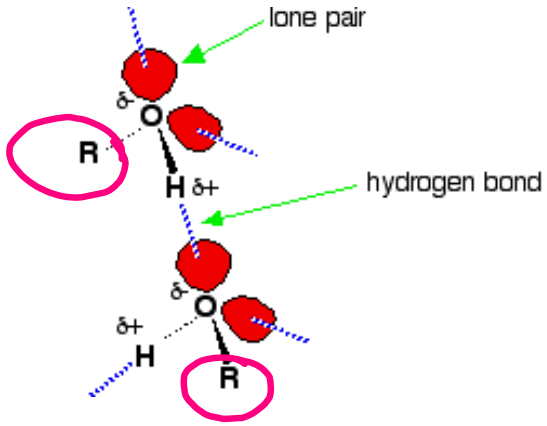


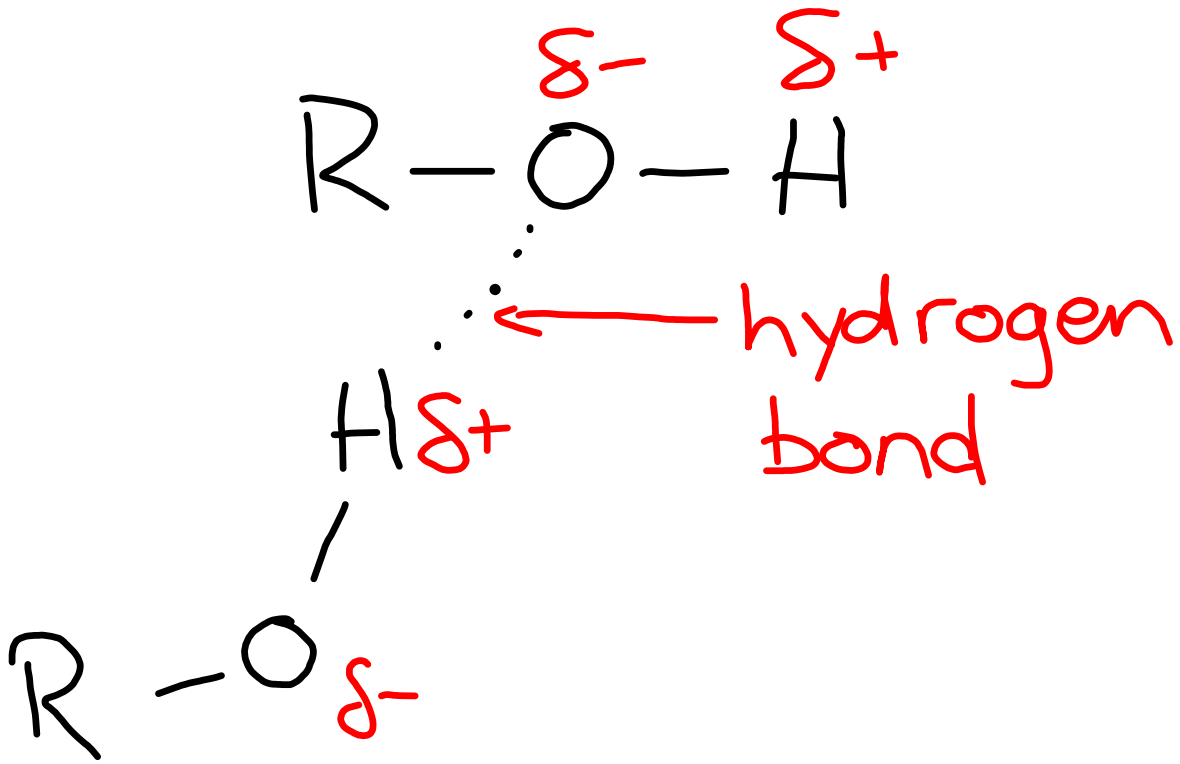
isopropyl alcohol (ℓ)

$CH_3-CH_2-CH_3$

propane (g)


δ-
H δ+
δ+


lone pair
δ-
O
R
H δ+
hydrogen bond
δ-
O
δ+
H
R


δ-
δ+
R – O – H
hydrogen bond
H δ+
R – O δ-

Notice that:

***The boiling point of an alcohol is always much higher than that of the alkane with the same number of carbon atoms.**

***The boiling points of the alcohols increase as the number of carbon atoms increases. The patterns in boiling point reflect the patterns in intermolecular attractions.**

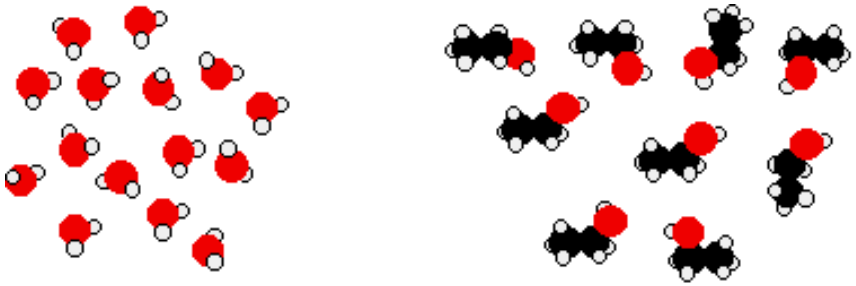
Solubility of alcohols in water

The small alcohols are completely soluble in water. Whatever proportions you mix them in, you will get a single solution.

However, solubility falls as the length of the hydrocarbon chain in the alcohol increases. Once you get to four carbons and beyond, the fall in solubility is noticeable, and you may well end up with two layers in your test tube.

The solubility of the small alcohols in water

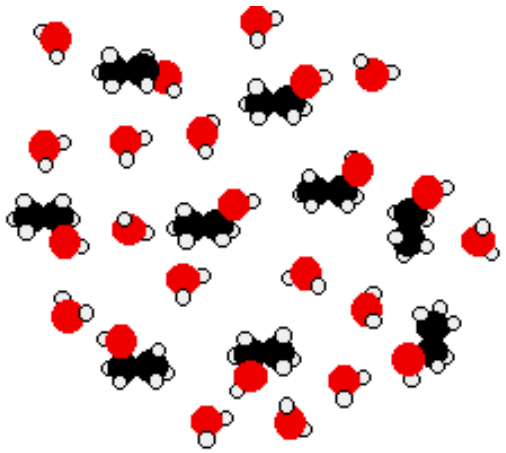
Consider ethanol as a typical small alcohol. In both pure water and pure ethanol the main intermolecular attractions are hydrogen bonds.



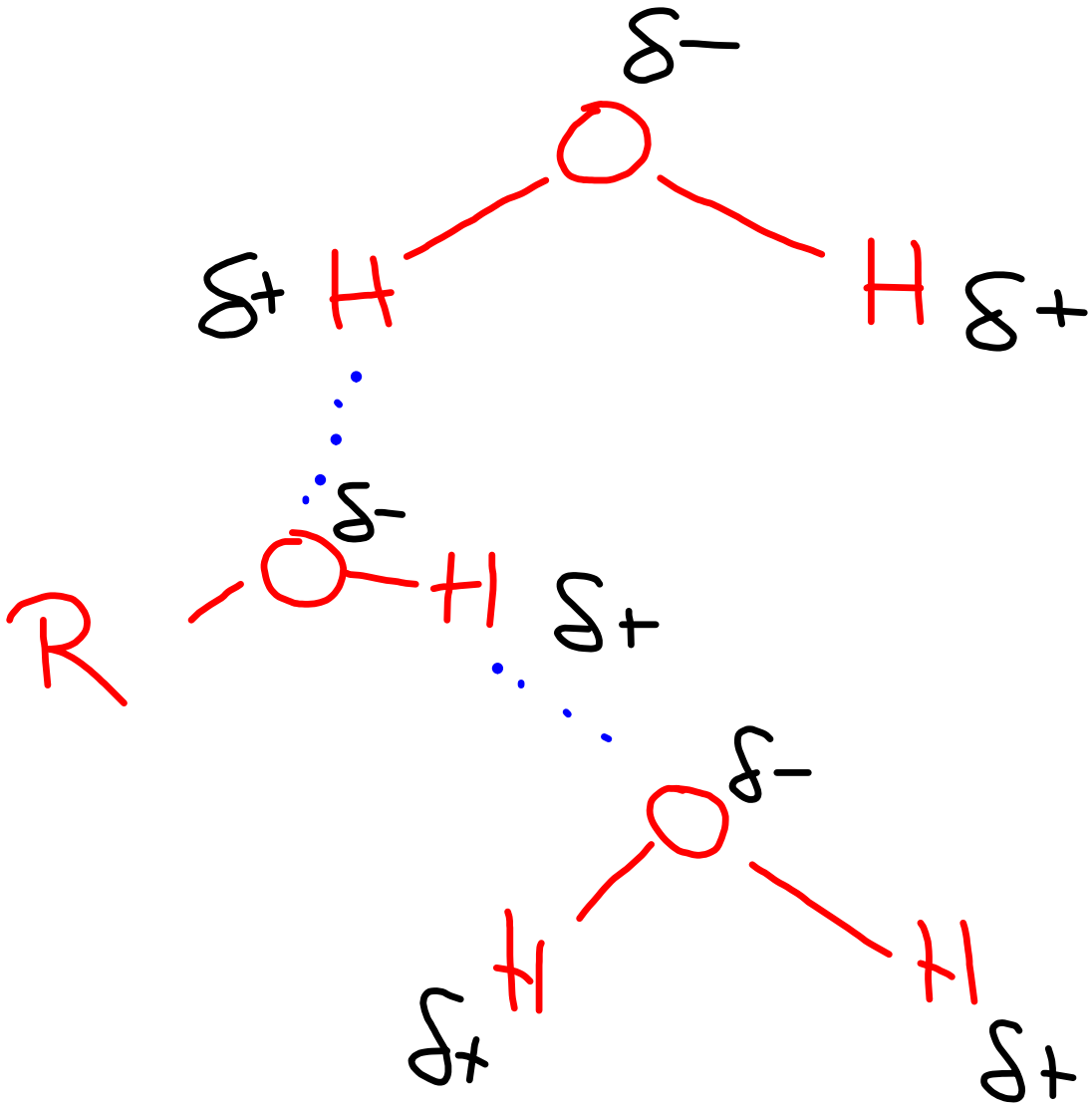
Both of these are held together mainly by hydrogen bonding.

In order to mix the two, you would have to break the hydrogen bonds between the water molecules and the hydrogen bonds between the ethanol molecules. It needs energy to do both of these things.

However, when the molecules are mixed, new hydrogen bonds are made between water molecules and ethanol molecules.

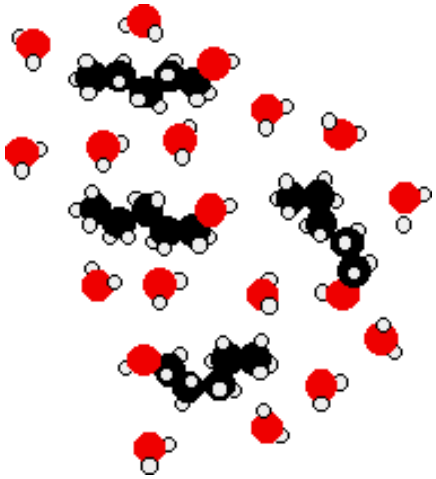


New hydrogen bonds are set up between ethanol and water molecules.


δ−
δ+
H
H
δ+
δ−
R
O
H
δ+
δ−
O
H
H
δ+
δ+

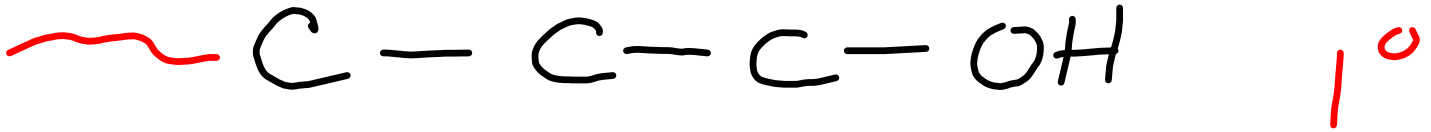
The lower solubility of bigger alcohols

Imagine what happens when you have got, say, 5 carbon atoms in each alcohol molecule.

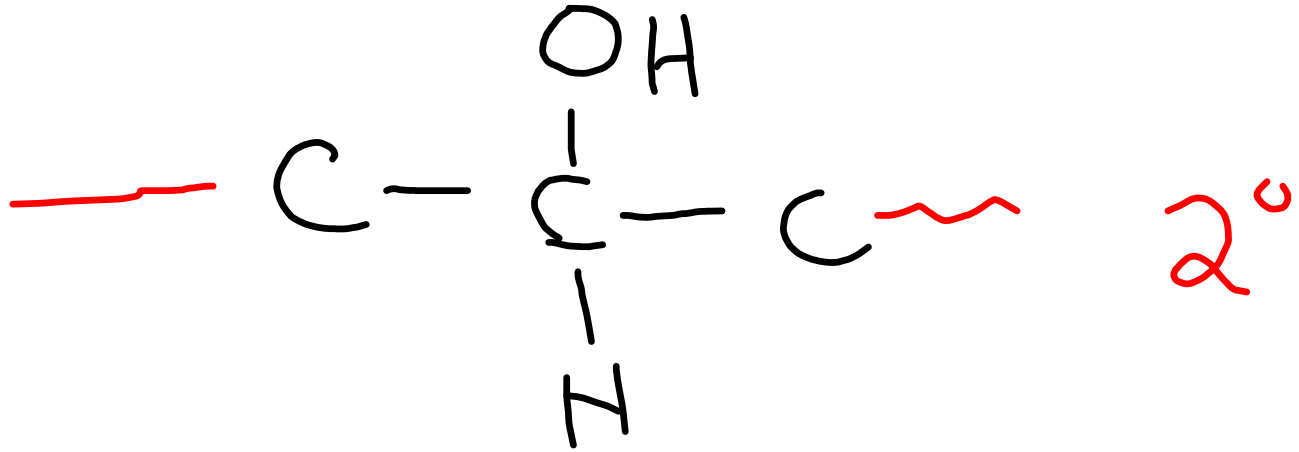


The -OH end of the alcohol molecules can form new hydrogen bonds with water molecules, but the hydrocarbon "tail" doesn't form hydrogen bonds

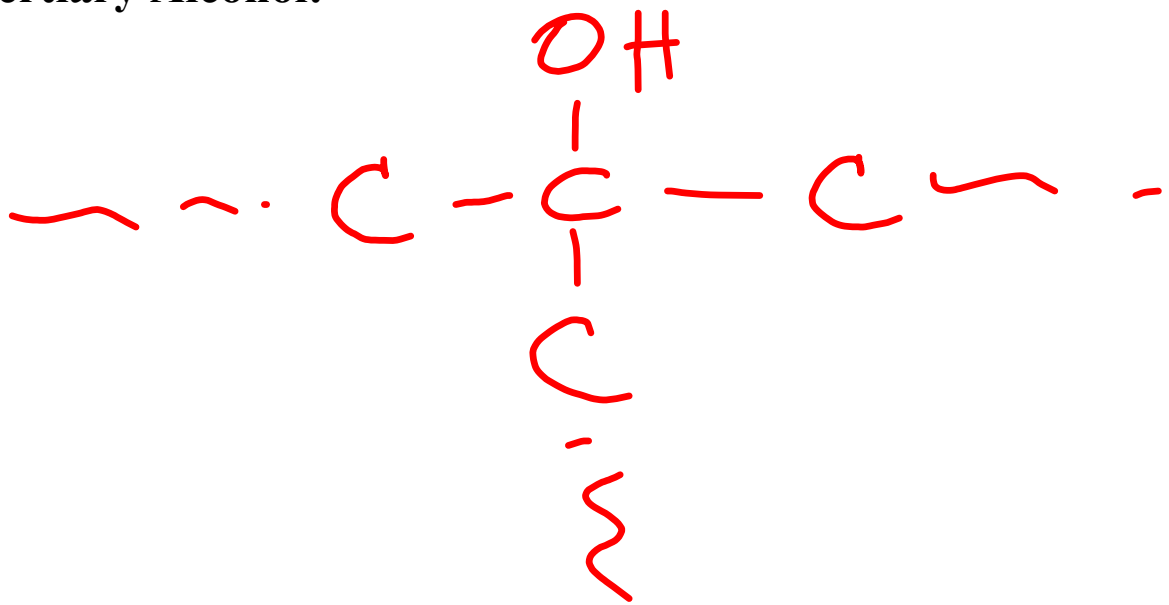
Primary alcohols:



Secondary Alcohols:



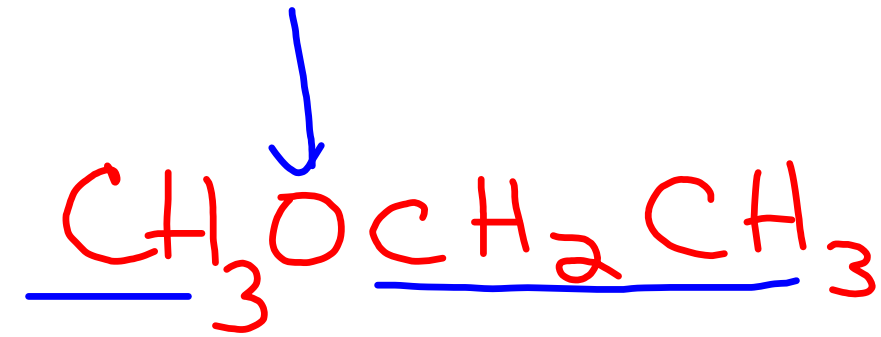
Tertiary Alcohol:



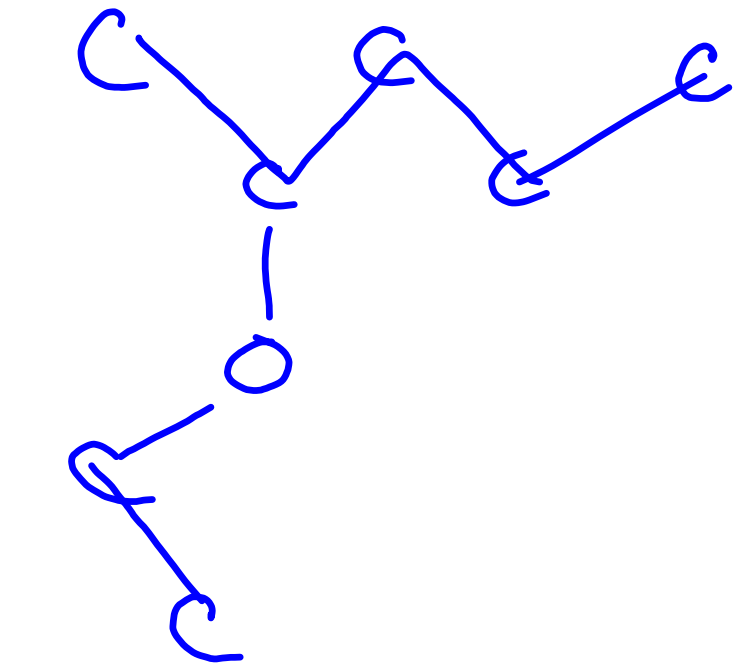
ethers

$R-O-R'$

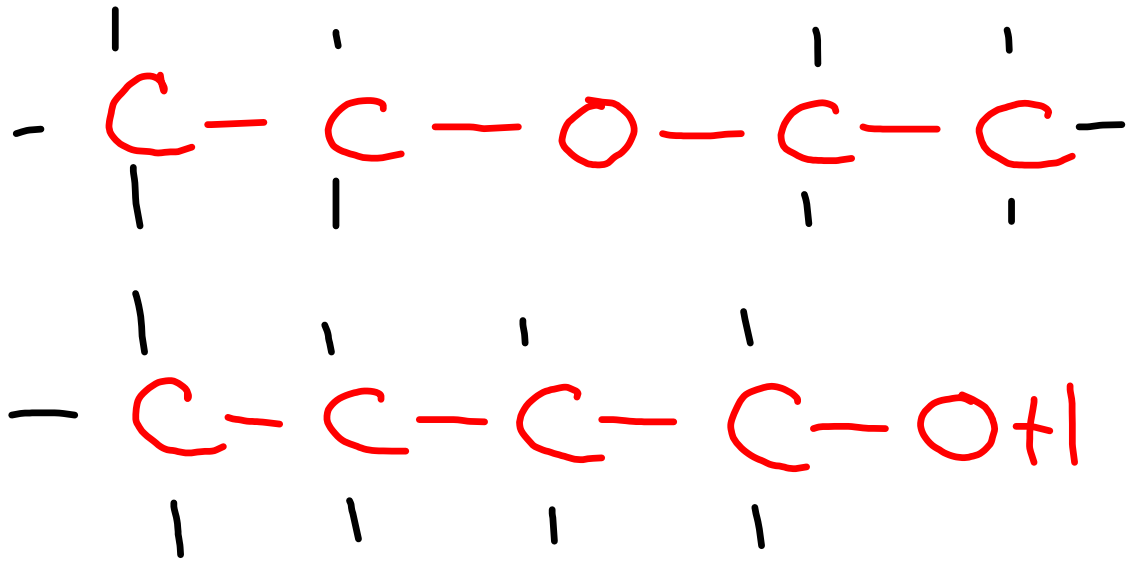
R_1-O-R_2



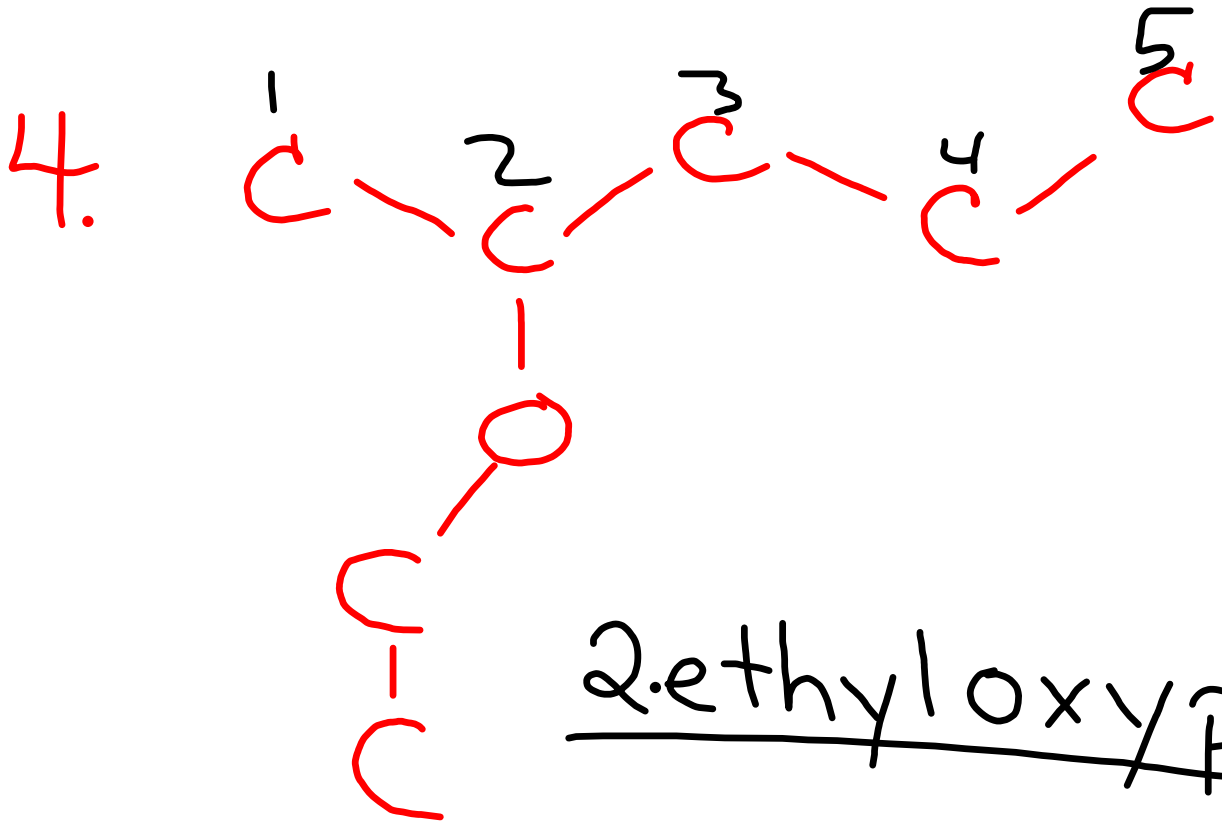
methyl ethyl ether



ethyl pentyl ether

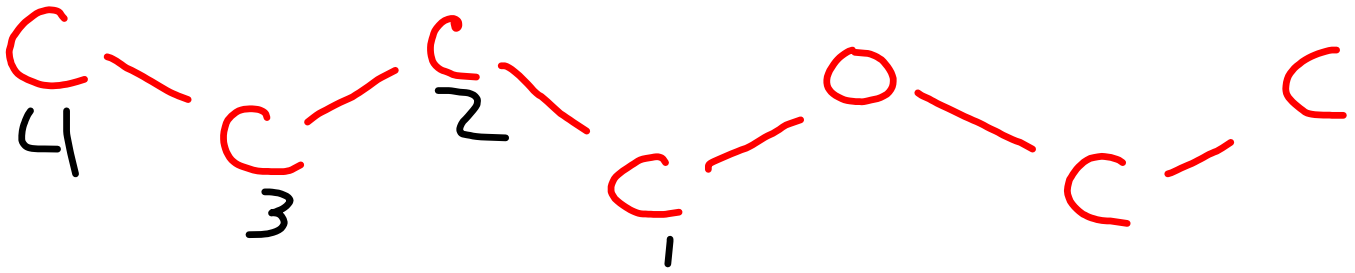

O
O
n

4.



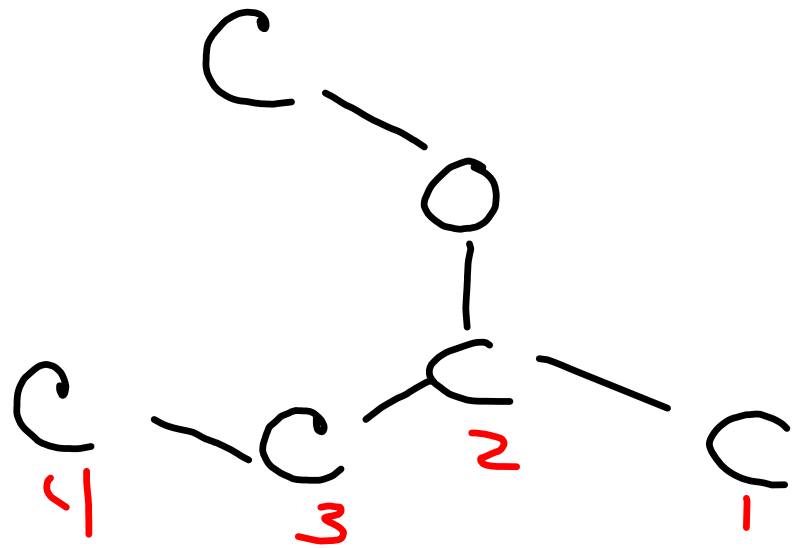
2-ethyloxypentane

ethyl pentyl ether

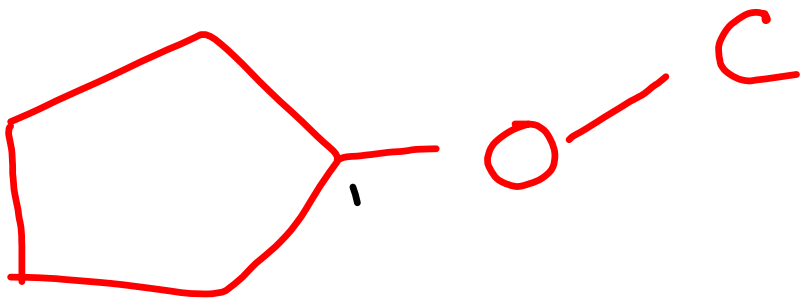


1-ethoxy butane

butyl ethyl ether



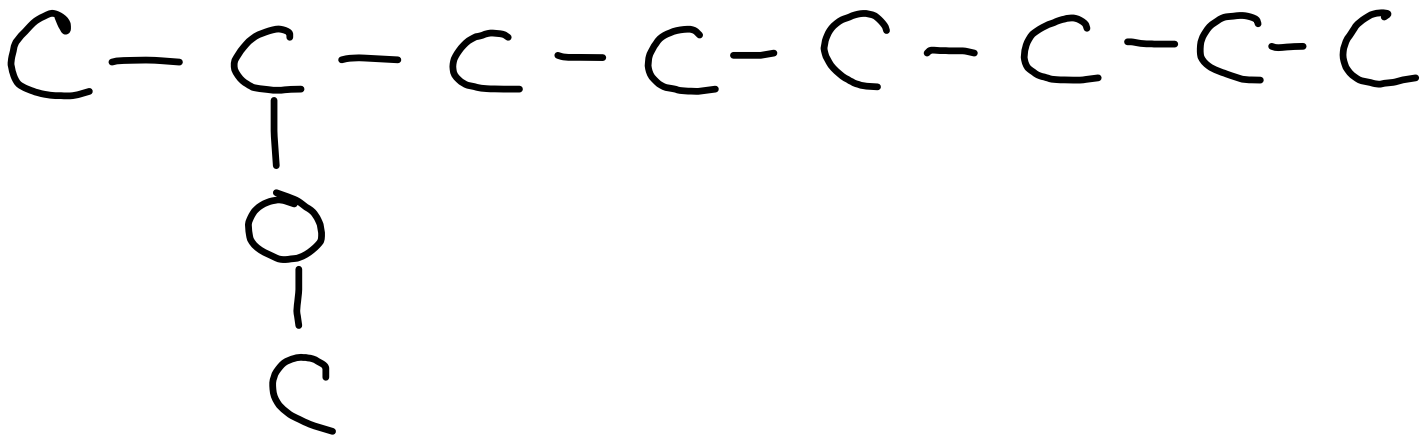
2-methoxy butane



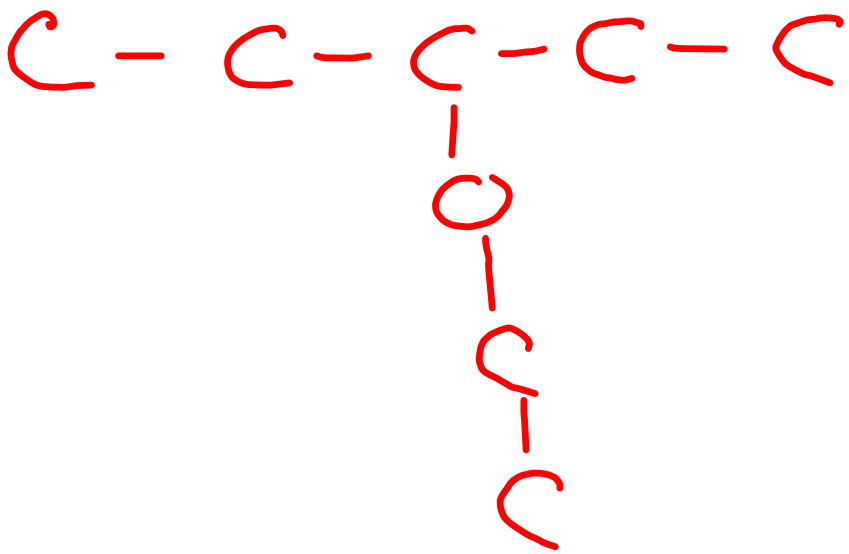
methyl cyclopentyl ether

1-methoxycyclopentane

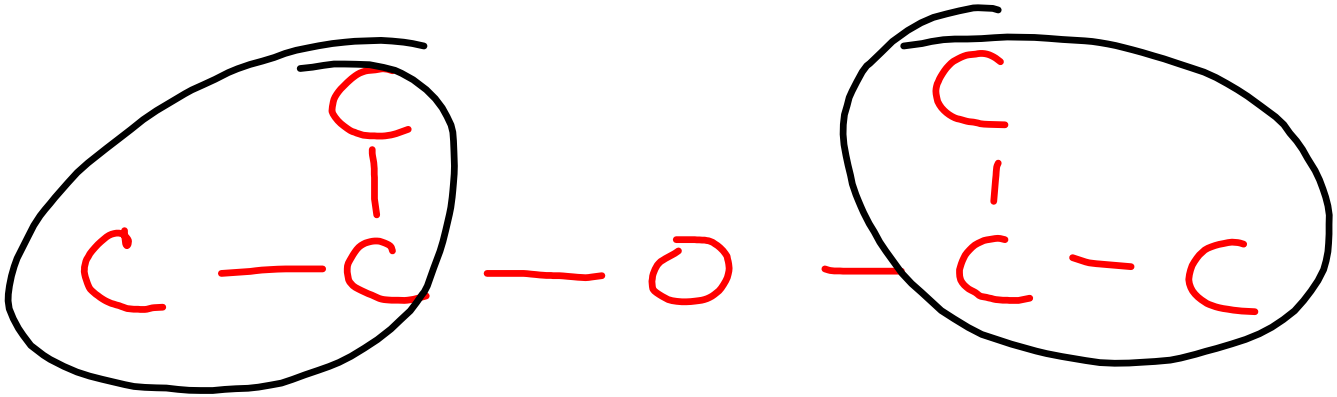
5. b. 2- methoxyoctane



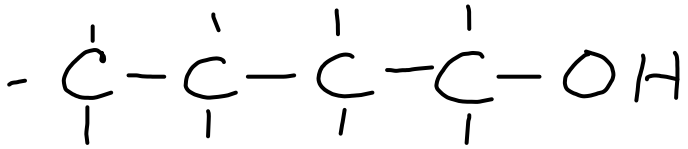
5 d. 3-ethoxypentane



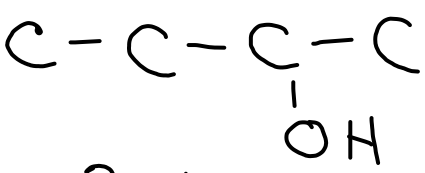
5. c



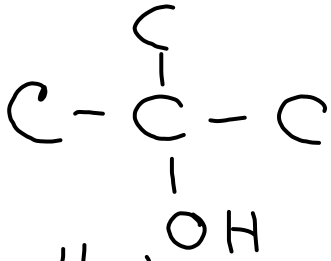
1. $C_4H_{10}O$



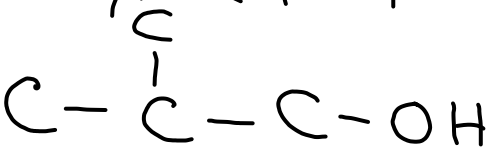
1-butanol



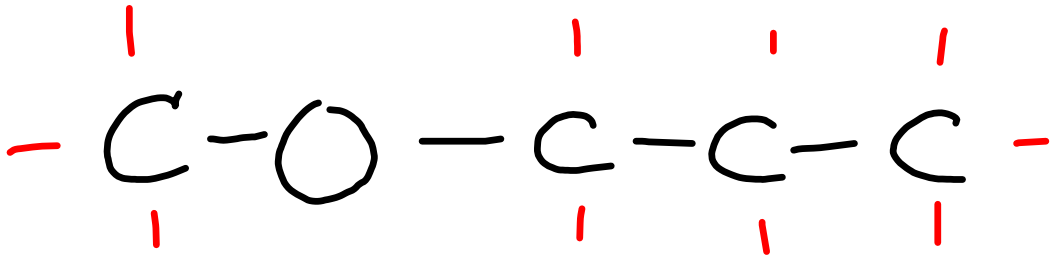
2-butanol



2-methyl-2-propanol



2-methyl-1-propanol

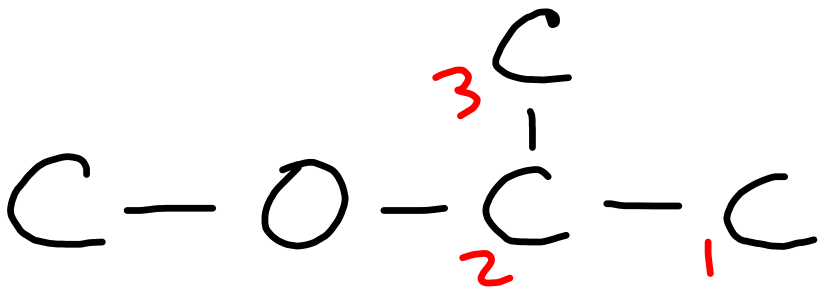


1- methoxypropane

methyl propyl ether

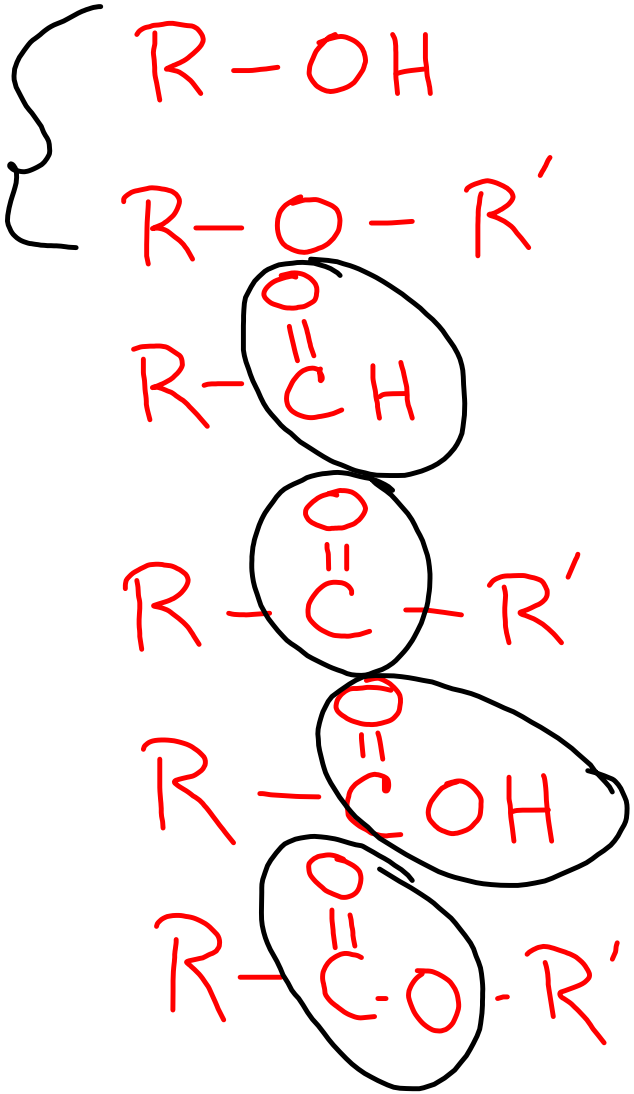
diethyl ether

1- ethoxyethane



isopropyl methyl ether

2-methoxypropane


R – OH
R – O – R′
R – C(=O) – H
R – C(=O) – R′
R – C(=O) – OH
R – C(=O) – O – R′

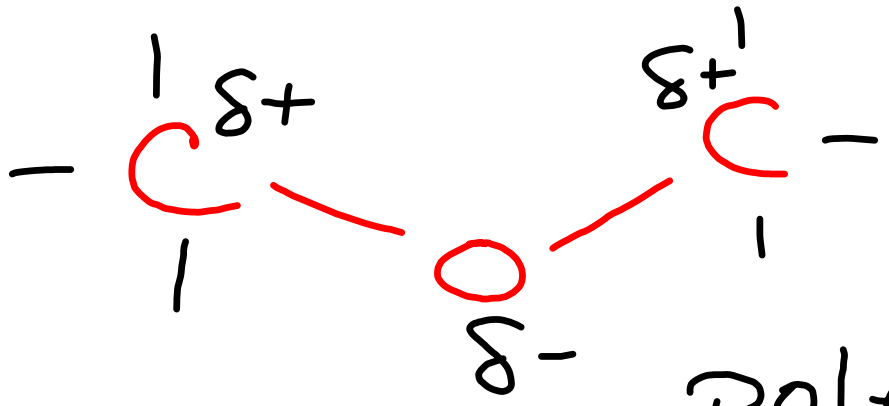
"like dissolves like"

Alkyl groups are nonpolar

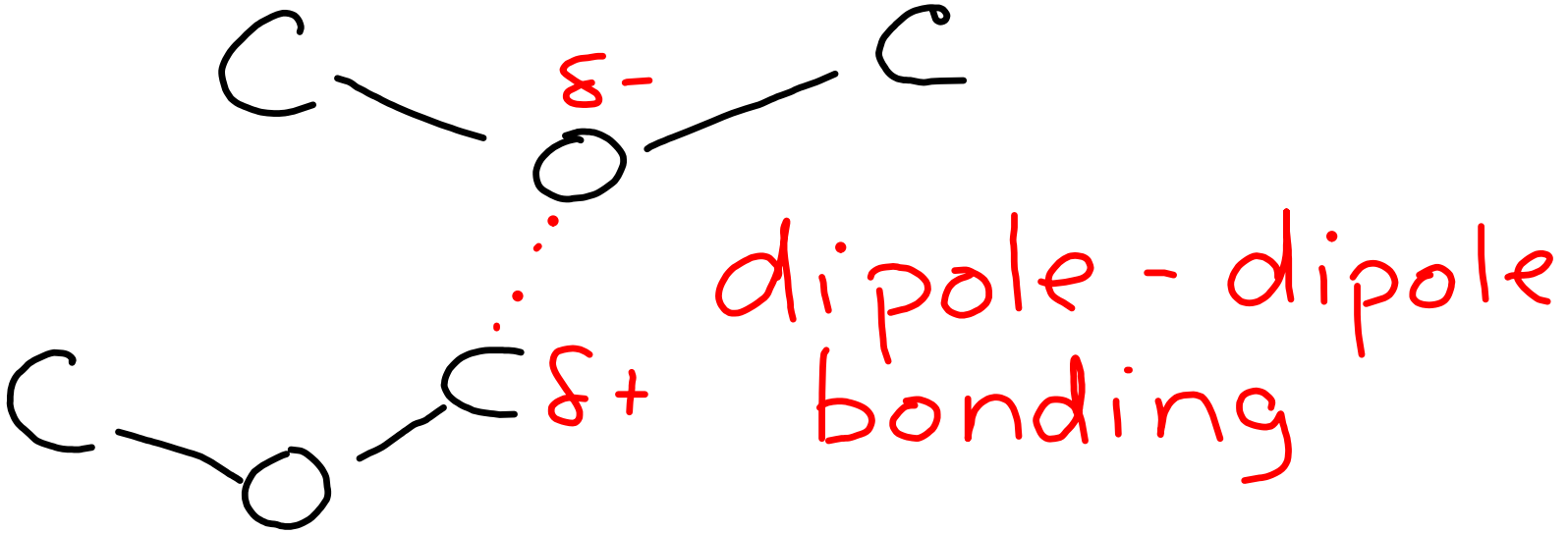
Alcohols if more than 5 carbon chain the alcohol will not dissolve.

Alcohols are polar.

Will bond with themselves and water through bonding.



poles not as strong as alcohols.


δ-
δ+
dipole - dipole
bonding

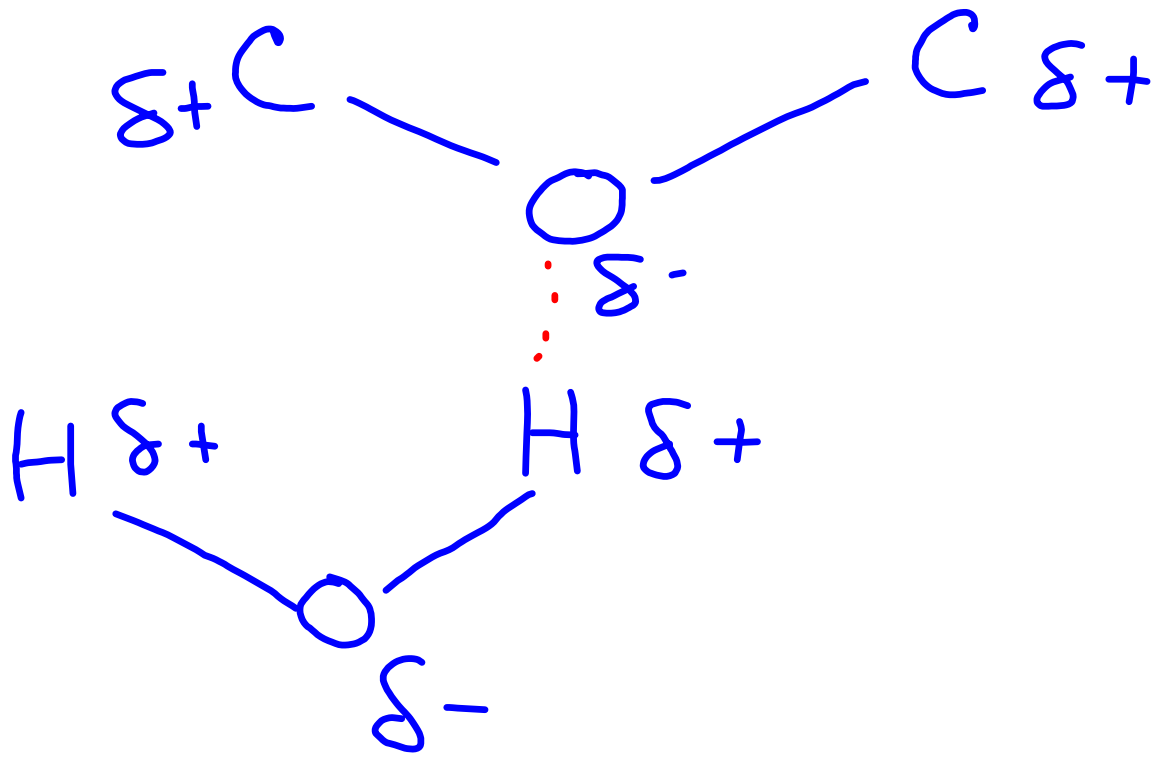
alcohols ether alkyl

hydrogen bonding > dipole-dipole > van der Waals

alcohols + H_2O Soluble 5 chains or less

ether + H_2O Soluble w/ Hydrogen Bonding and Dipole Dipole bonding

not soluble


δ+
C
C
δ+
O
δ-
H
δ+
H
δ+
O
δ-