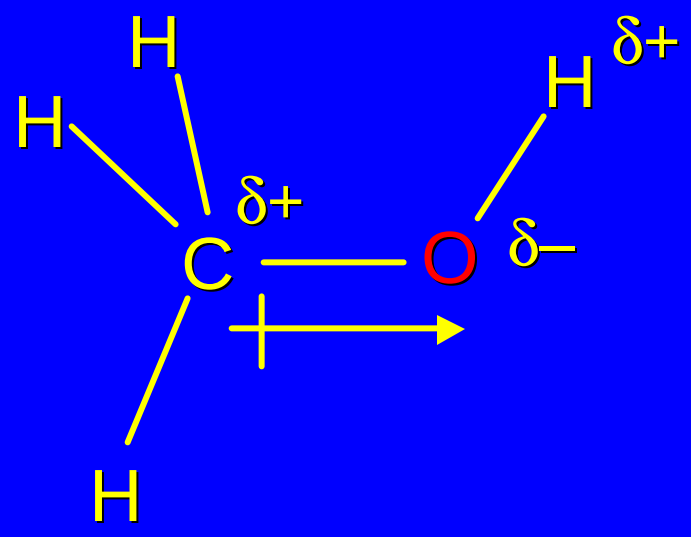
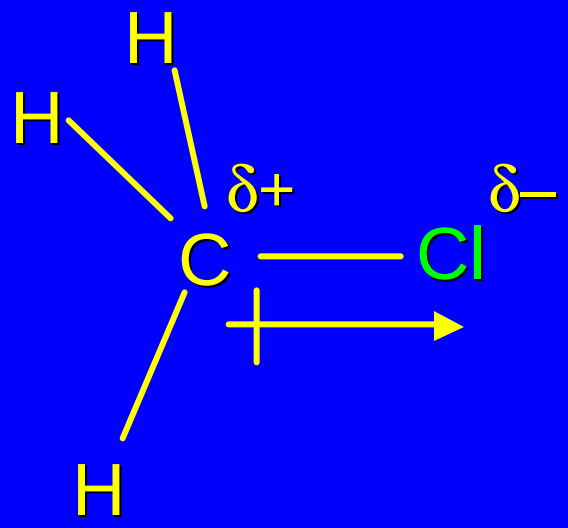
4.4
Bonding in Alcohols and Alkyl Halides

Dipole Moments

alcohols and alkyl halides are polar



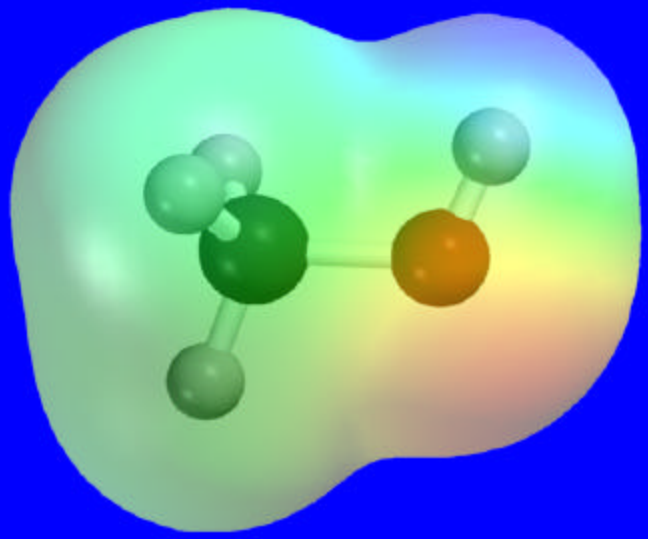
m = 1.7 D

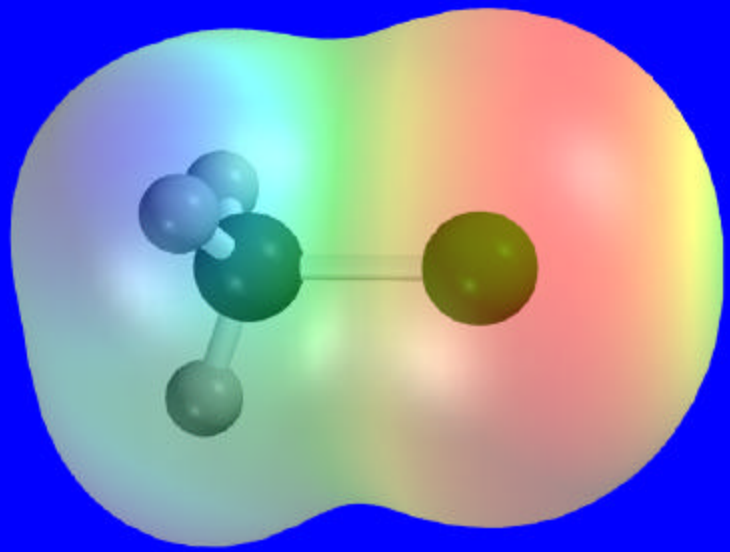


m = 1.9 D

Dipole Moments

alcohols and alkyl halides are polar

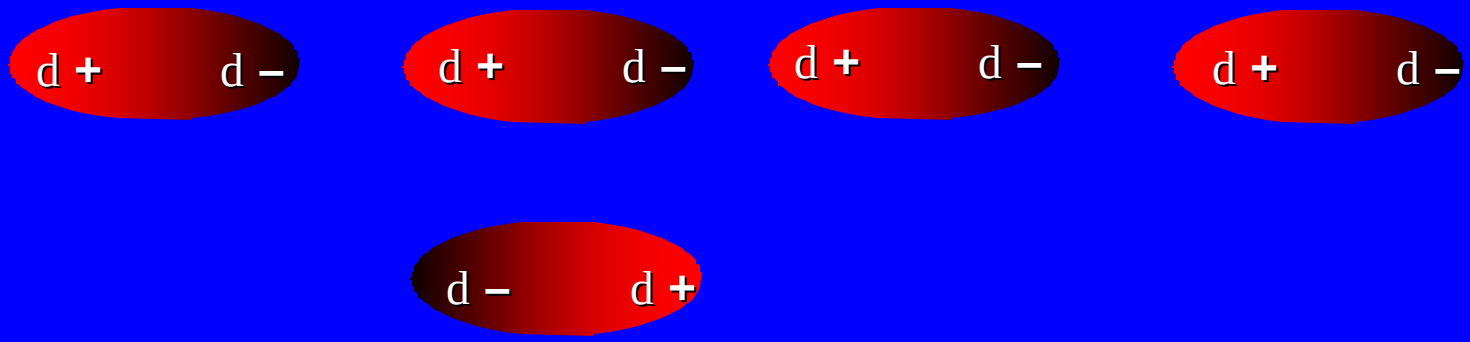




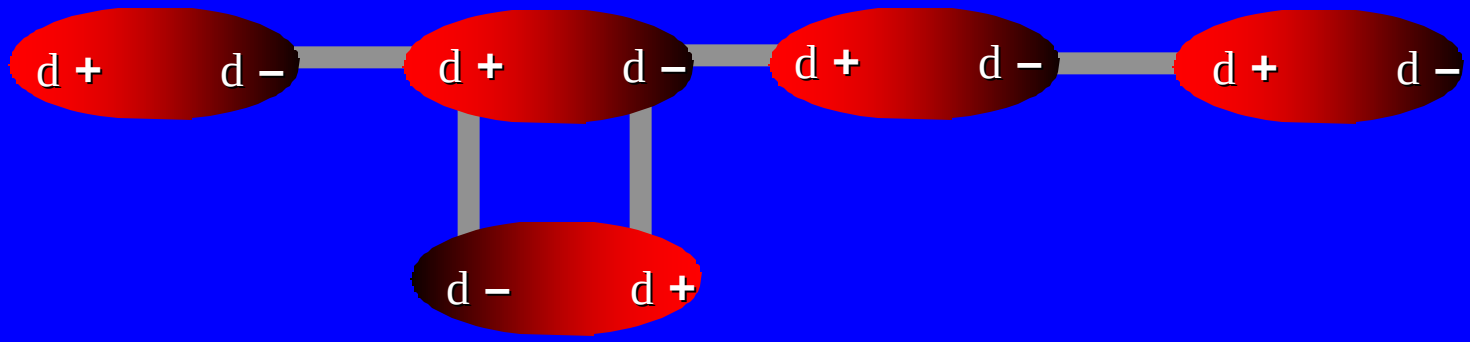
m = 1.7 D

m = 1.9 D

Dipole-Dipole Attractive Forces



Dipole-Dipole Attractive Forces



4.5
Physical Properties of Alcohols and Alkyl Halides: Intermolecular Forces

Boiling point

Solubility in water

Density

Effect of Structure on Boiling Point

	$CH_3CH_2CH_3$	CH_3CH_2F	CH_3CH_2OH
Molecular weight	44	48	46
Boiling point, °C	-42	-32	+78
Dipole moment, D	0	1.9	1.7

Effect of Structure on Boiling Point

	$CH_3CH_2CH_3$	
Molecular weight	44	Intermolecular forces are weak.
Boiling point, °C	-42	Only intermolecular forces are induced dipole-induced dipole attractions.
Dipole moment, D	0	

Effect of Structure on Boiling Point

	CH_3CH_2F
Molecular weight	48
Boiling point, °C	-32
Dipole moment, D	1.9

A polar molecule; therefore dipole-dipole and dipole-induced dipole forces contribute to intermolecular attractions.

Effect of Structure on Boiling Point

	CH_3CH_2OH	
Molecular weight	46	Highest boiling point; strongest intermolecular attractive forces.
Boiling point, °C	+78	Hydrogen bonding is stronger than other dipole-dipole attractions.
Dipole moment, D	1.7	

Figure 4.4 Hydrogen bonding in ethanol

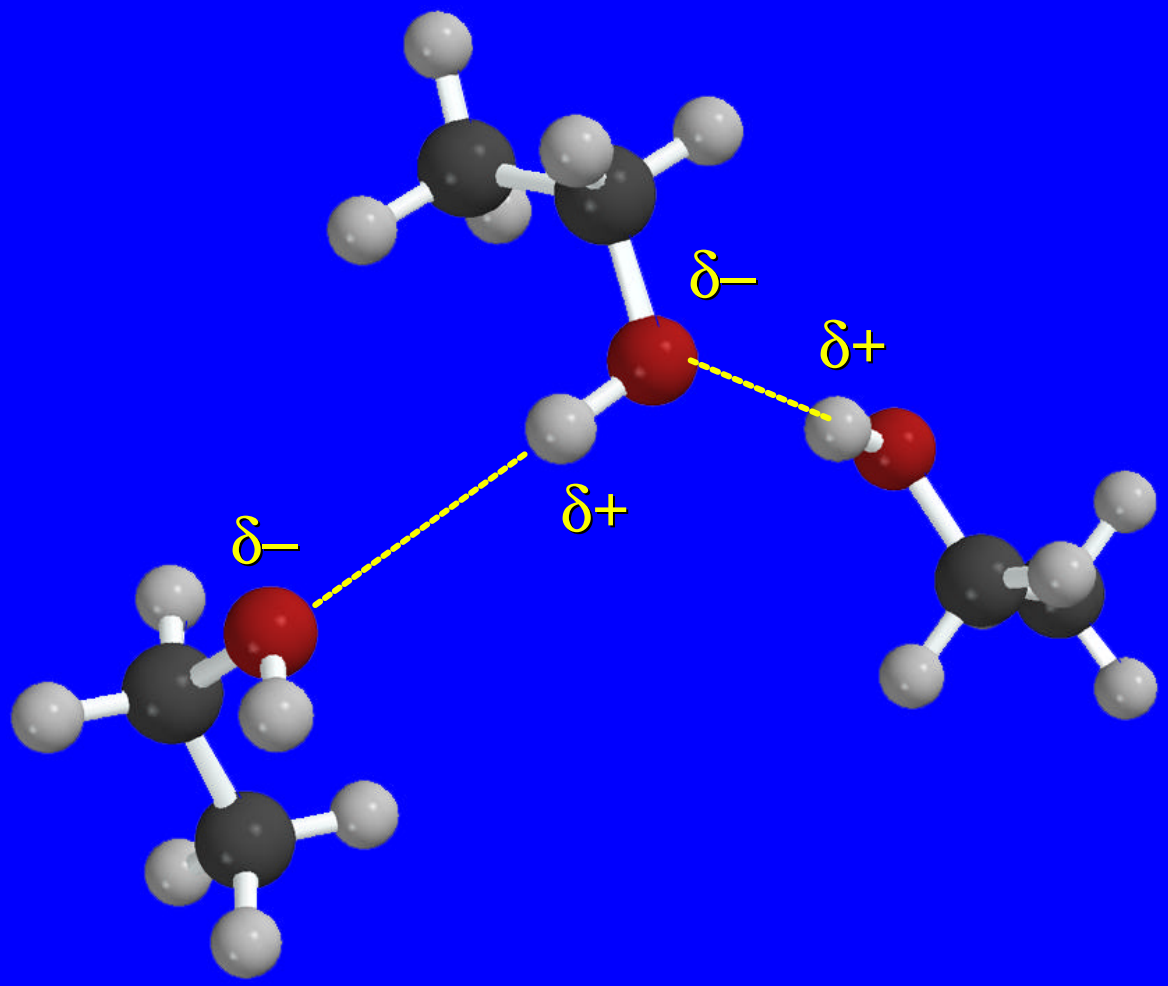
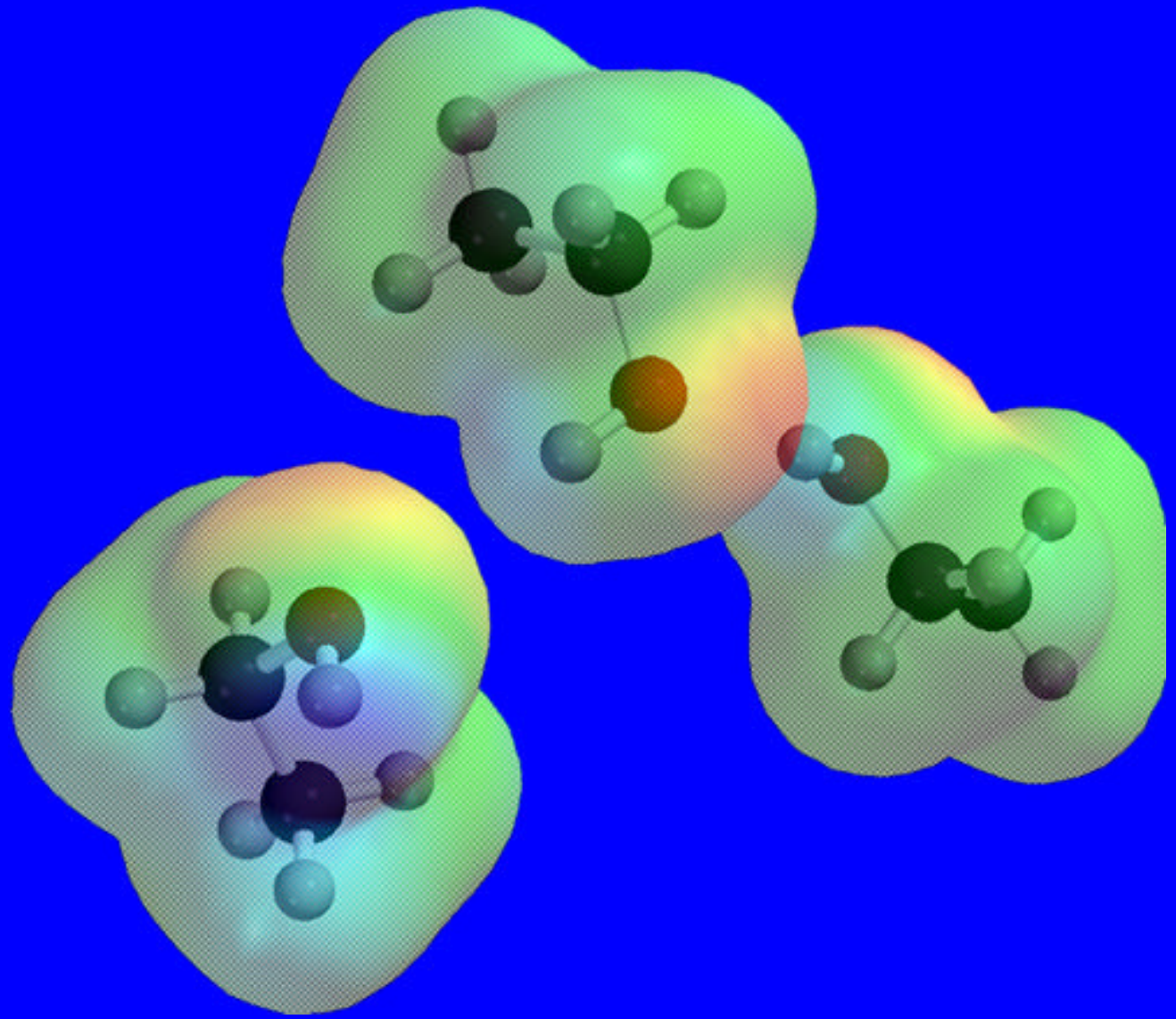


Figure 4.4 Hydrogen bonding in ethanol



Boiling point increases with increasing number of halogens

Compound	Boiling Point
CH_3Cl	-24°C
CH_2Cl_2	40°C
$CHCl_3$	61°C
CCl_4	77°C

Even though CCl_4 is the only compound in this list without a dipole moment, it has the highest boiling point.

Induced dipole-induced dipole forces are greatest in CCl_4 because it has the greatest number of Cl atoms. Cl is more polarizable than H.

But trend is not followed when halogen is fluorine

Compound	Boiling Point
CH_3CH_2F	-32°C
CH_3CHF_2	-25°C
CH_3CF_3	-47°C
CF_3CF_3	-78°C

But trend is not followed when halogen is fluorine

Compound	Boiling Point
CH_3CH_2F	-32°C
CH_3CHF_2	-25°C
CH_3CF_3	-47°C
CF_3CF_3	-78°C

Fluorine is not very polarizable and induced dipole-induced dipole forces decrease with increasing fluorine substitution.

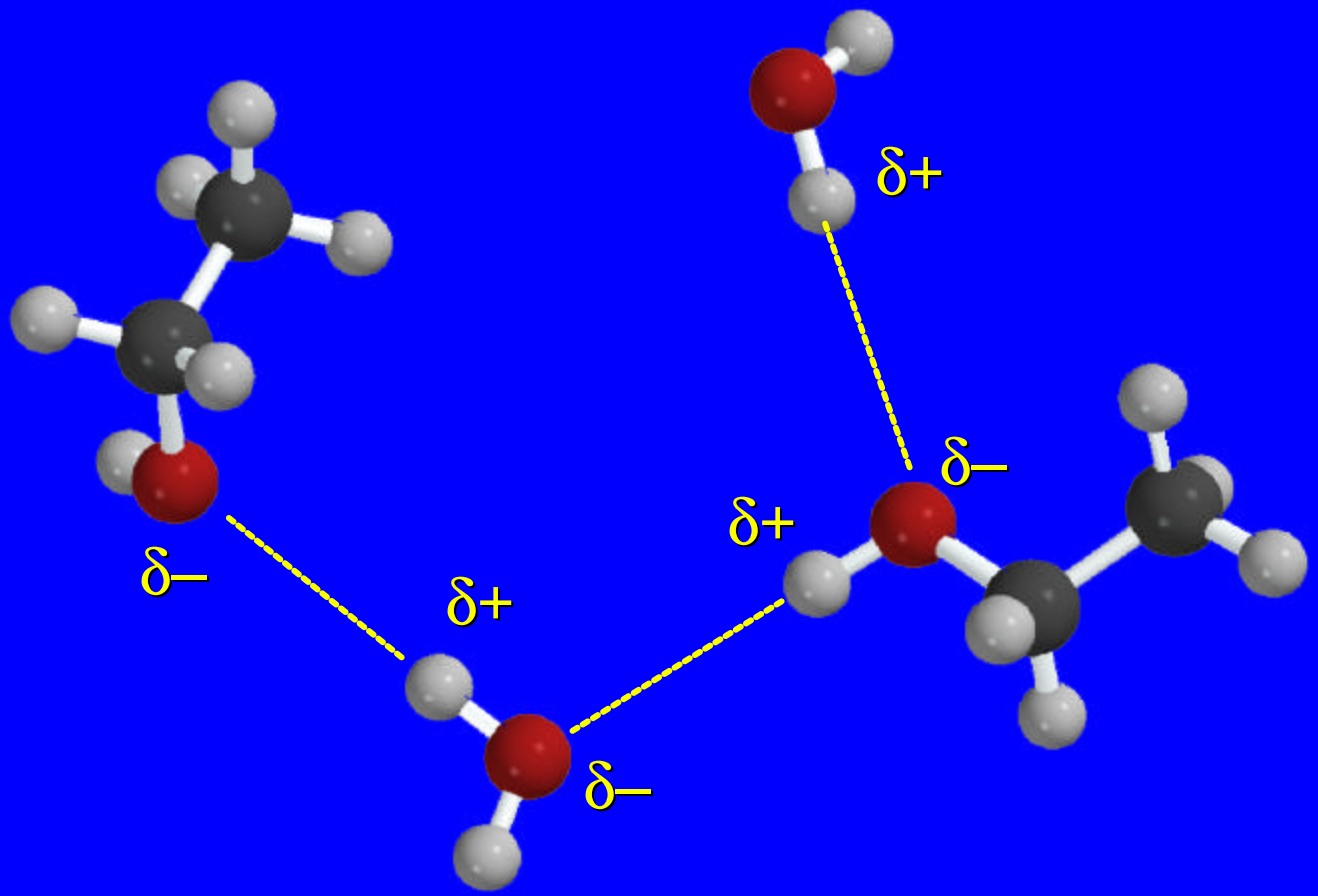
Solubility in water

Alkyl halides are insoluble in water.

Methanol, ethanol, isopropyl alcohol are completely miscible with water.

The solubility of an alcohol in water decreases with increasing number of carbons (compound becomes more hydrocarbon-like).

Figure 4.5 Hydrogen Bonding Between Ethanol and Water



Density

Alkyl fluorides and alkyl chlorides are less dense than water.

Alkyl bromides and alkyl iodides are more dense than water.

All liquid alcohols have densities of about 0.8 g/mL.