



## Ammonia, NH3: Single Bonds:

One molecule of Nitrogen and three of Hydrogen



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## Hydrogen bonding through nitrogen:

## Example: Ammonia, NH<sub>3</sub>

All organic containing -N-H group can form intermolecular hydrogen bonds. An example is the organic group of compounds known as primary amines, which have the general formula of RNH<sub>2</sub>



## Hydrogen bonding through fluorine:

The only fluorine compound with intermolecular hydrogen bonding is hydrogen fluoride.



Hydrogen bonding (HF)n in HF solid state

You can see the relationship between chain length and points of contact using the skeletal formula of the alkanes:



Because of their shape, the molecules of the alkanes fit together well, and pack very closely together. There are points of contact all along the chain. The longer the chain, the more points of contact there are.

## Branched Alkanes:

The more branching in the molecule, the fewer points of contact between adjacent molecules; i.e. they do not pack together as well. This leads to a decrease ing the overall intermolecular force of attraction between molecules and decreases the boiling temperature.

## Alcohols:

Alcohols are homologous series of compounds with the general formula C<sub>n</sub>H<sub>2n+1</sub>OH

They contain an -O-H group and can therefore form intermolecular hydrogen cous in addition to London forces. This additional bonding has an effect on the boiling emperature of alcohols when compared with the equivalent alkane, as is shown in the phowing table.

Alcohol	Electrons	temp /K	Alkane 31	Electrons	Boiling temp /K
CIDICO	18		СНЗСНЗ	18	184
СНЗСН2ОН	26	352	Ch3CH2CH3	26	231
CH3CH2CH2OH	34	370	CH3CH2CH2CH3	34	267
CH3CH2CH2CH2OH	42	390	CH3CH2CH2CH2CH3	36	303

Let us consider the case of methanol (CH<sub>3</sub>OH) and ethane (CH<sub>3</sub>CH<sub>3</sub>)

Both molecules have a similar chain length and also have the same number of electrons. If the intermolecular interactions in each were London forces, then their boiling point would be almost identical. However, the boiling points of the alcohol is higher than that of the alkane. This increase can be attributed to the hydrogen bonding that exists between methanol molecules, which does not exist between molecules of ethane. The additional force of attraction increases the energy required to separate the molecules.

You will notice the same tend in the other compounds in the table

It is sometimes states that the predominant bonding in alcohols is hydrogen bonding. We have already mentioned that this is now alway the case. The following table provides evidence that for the first few members of the alcohols series hydrogen bonding is predominant, but that London forces eventually predominate as the chain length increases.



The slightly negative end of the water molecules at r C the sodium ions sufficiently to remove them from the lattice; The sodium ions then become surrounded by water molecules, as shown. The interaction between the sodium ions and the water morecules is called an ion-dipole interaction.

The slight positive end of the water folcoules attract the Chlorine ions sufficiently to remove them from the lattice. The chlorine ions then get surrounded by water molecules, and form hydrogen bonds (as chlorine has a higher electronegativity than hydrogen)

The process is called 'hydration', and the energy released is known as the 'hydration energy'.

## Dissolving Alcohols: Compounds that can form hydrogen bonds with water

Alcohols contain -O-H group and can therefore form hydrogen with water.

The diagram shows a molecule of ethanol forming a hydrogen bond to water:



Ethanol and water mix in all proportions. The hydrogen bonding between the ethanol and water molecules is similar in strength to the hydrogen bonding in pure ethanol and in pure water .

The solubility of alcohols in water decreases with increasing hydrocarbon chain length as London forces predominate between the alcohols molecules.

## Water is a poor solvent for compounds

## Compounds that cannot form hydrogen bonds with water:

## Non-polar molecules such as the alkanes do not dissolve in water.

#### Why?

The attraction between the alkane molecules and water molecules is not sufficiently strong to disrupt the hydrogen bonded system between the water molecules.

## Many polar molecules also have limited solubility in water.

## Why?

This is because they either do not form hydrogen bonds with water, or the hydrogen bonds they form are weak compared with the hydrogen bonds in water.

Ethoxyethane, CH<sub>3</sub>CH<sub>2</sub>OCH<sub>2</sub>CH<sub>3</sub> is polar. and yet is almost totally immiscible with water. The forces of attraction between ethoxyethane and water molecules are not large enough to replace the relatively strong hydrogen bonding between the water molecules.

Halogenoalkanes are also not very soluble in water for similar reasons. They are much more soluble in ethanol, and this is why some reactions of halogenoalkanes are carried out in medium of aqueous ethanol.

# TO DISSOLVE AN SUBSTANCE IT REQURES THE FORCES OF ATTRACTION BETWEEN THE MOLECULE AND WATER TO BE STRONGER THAN THAT OF THEM BETWEEN THE WATER MOLECULES. Non-Aquious solvents:

The 'rule-of-thumb' is that; 'like dissolves like'. So if you're searching for a solvent for a non-polar substance or a substance that has a substantial non-polar part to its molecule, then liquids that contain similar molecules are often the answer.

For example, alkanes are soluble in one another. Crude oil is a complex mixture of alkanes dissolved in each other.

Non-polar bromine dissolves readily in non-polar hexane, and this solution is commonly used to test for unsaturation in molecules. It is more convenient to use than brome water, since the molecules being tested will be also soluble in hexane, whereas they are likely to be insoluble in water.

## DISSOLVING SOLUTIONS: LIKE FOR LIKE (NON-POLAR FOR NON-POLAR AND POLAR FOR POLAR)