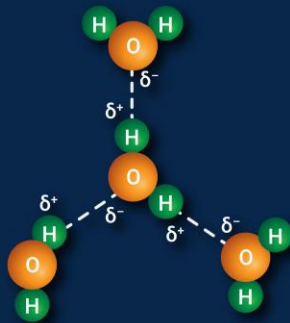


CHEMICAL BONDING - L10



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Hydrogen Bonding

Strongest dipole-dipole interaction is **H - Bonding**

Attractive force which binds
the **H atom** of one molecule

with the **E.N. atom (F, O, N &
sometimes Cl)** of another molecule



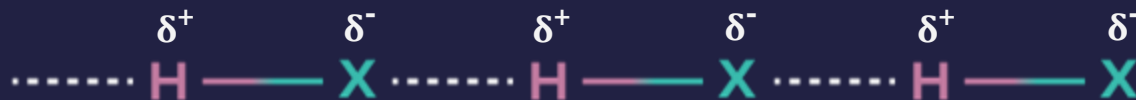


Hydrogen Bonding

H is bonded **covalently** to E.N. element '**X**'

Shared pair of electrons moves far **away** from the **H** atom

H acquires δ^+ charge & **X** acquires δ^- charge





Main Conditions for Hydrogen Bond

Hydrogen should be **covalently bonded**
to **highly E.N. atoms** like F, O & N

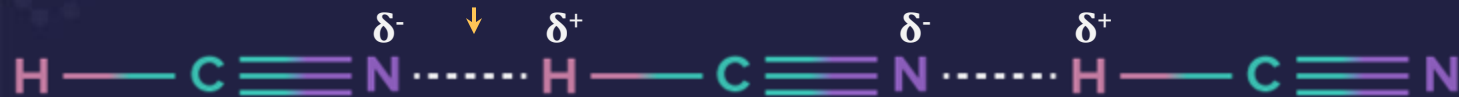
Atleast **one lone pair** on E.N. element





H - bonding in HCN

H-Bonding



E.N. of C (sp) & N ↑



Hydrogen Bond

Strength of the H bond is determined by the coulombic interaction b/w the **lone pair of the E.N. atom & H atom**





Factors Affecting Strength of H - bonding

Ease of donation of
lone pair of E.N. atom ↑

Strength of H - bonding ↑

N

>

O

>

F

Decreasing tendency to donate lone pair

Higher electronegativity difference



Greater δ^+ charge on H - atom



Strength of H - bonding ↑





Remember!!



To compare strength of H - bond

First check $\Delta \text{E.N.}$ and then
tendency to donate lone pair





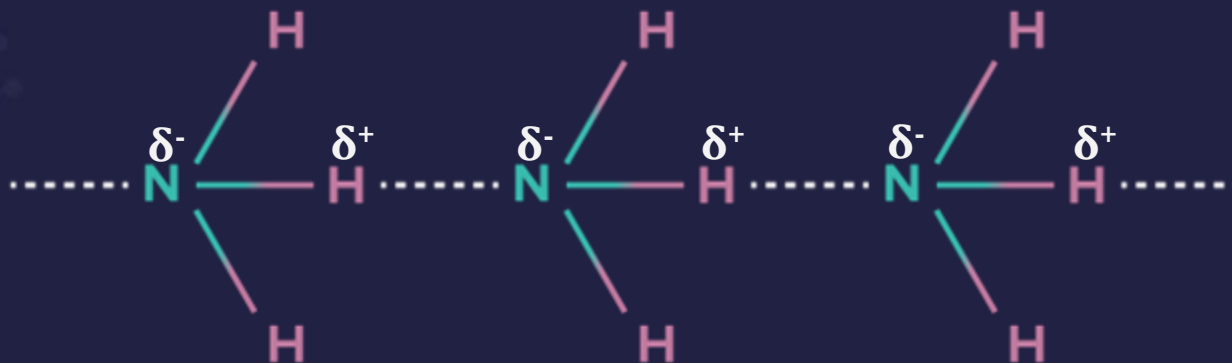
Arrange the following in the increasing order of strength of H - bond.





H - Bonding in Ammonia

$\text{NH}_3 (\text{g})$



Degree of H bond

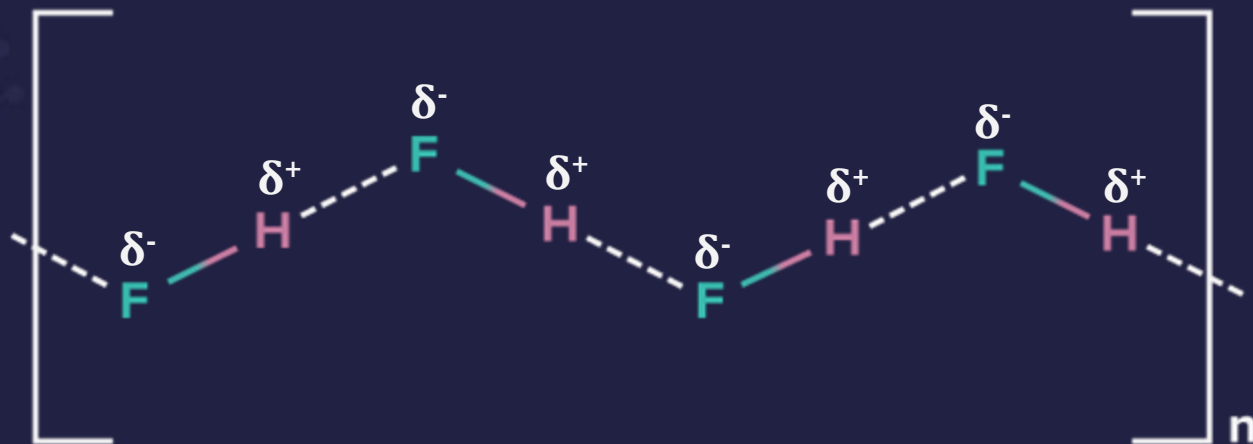
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2



H - Bonding in HF

In **solid** and **liquid** state



Degree of H bond

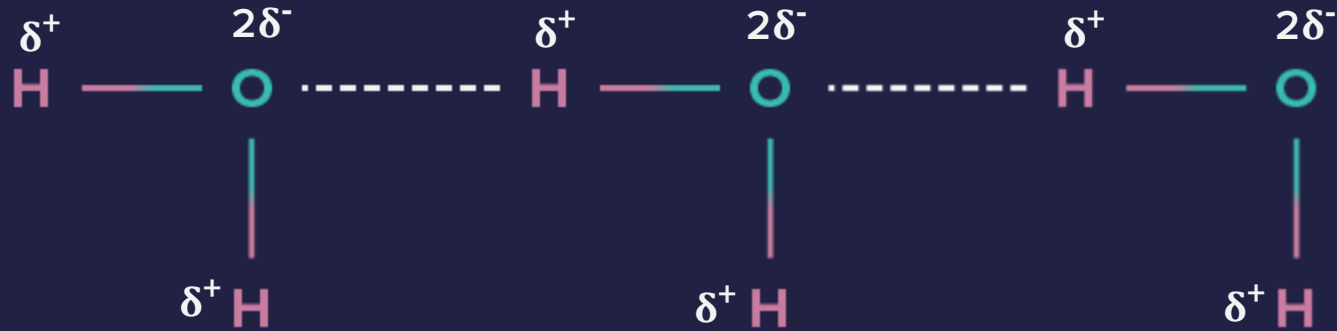
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2





H - Bonding in Water



(Degree of H bond)liquid

=

2

(Degree of H bond)ice

=

4





Out of H_2O & HF , which will have higher melting point?





Extent of H - bonding

Degree of H - bonds

Strength of H - bonding

Dominant factor

Order of M.P. :

H₂O

>

HF



Hydrogen Bonding



Magnitude of Hydrogen bonding depends on the **physical state** of the compound

Maximum

Solid state

Minimum

Gaseous
state



Hydrogen Bond

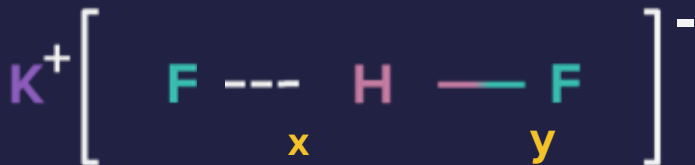
H - Bond

Energy varies
between
8 to 42 kJ mol⁻¹

Determines the
structure &
properties of
many compounds

Symmetrical H-bonding

Very **strong H-bonding** occurs in the alkali metal hydrogen fluorides of formula **M [HF₂]**



Bond lengths : **x = y = 113 pm**

Bond energy
of **both H-F**

=

163 kJ/mol

Types of H - Bonding

H - Bonding

Intermolecular

Between two or
more molecules

Intramolecular

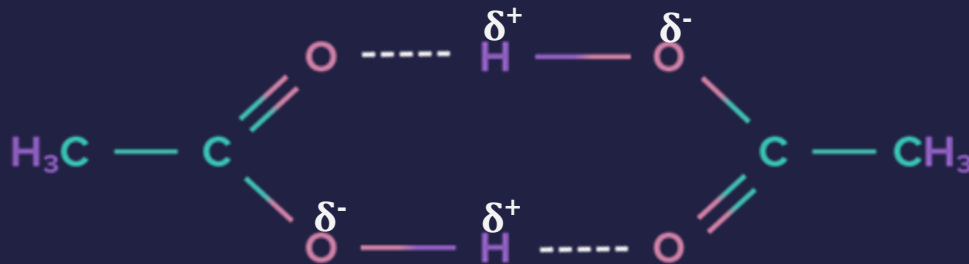
Within a molecule



Examples of Intermolecular H - Bonding

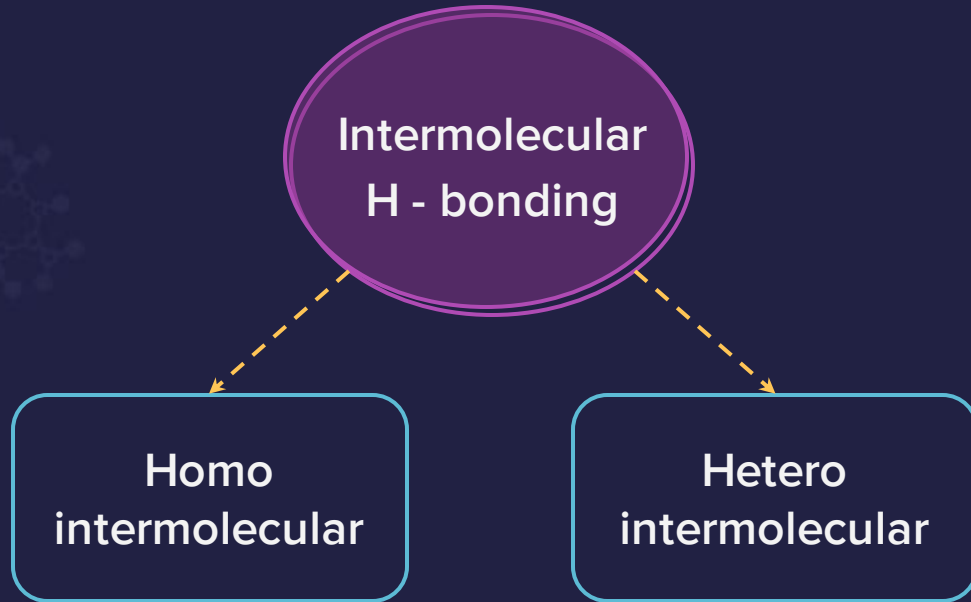


Boric Acid (solid state)

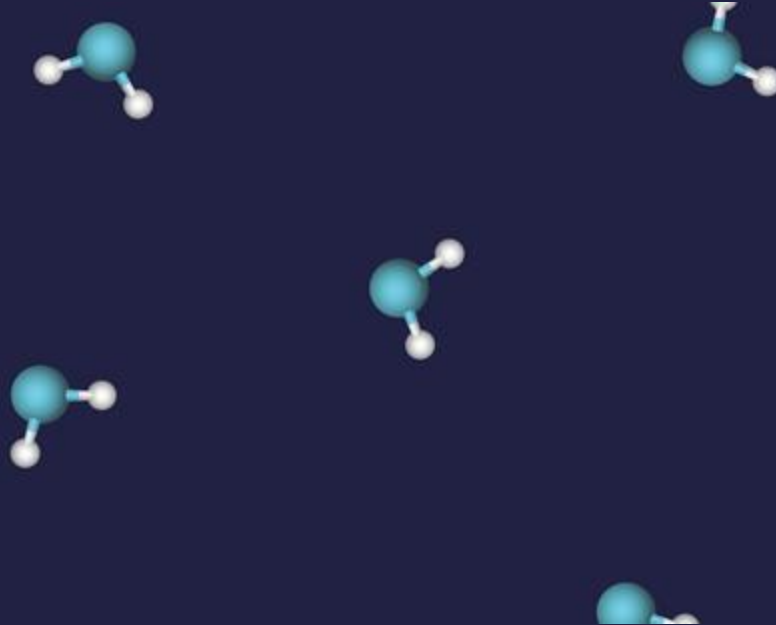


Acetic Acid

Intermolecular H - bonding



Homo Intermolecular H - Bonding

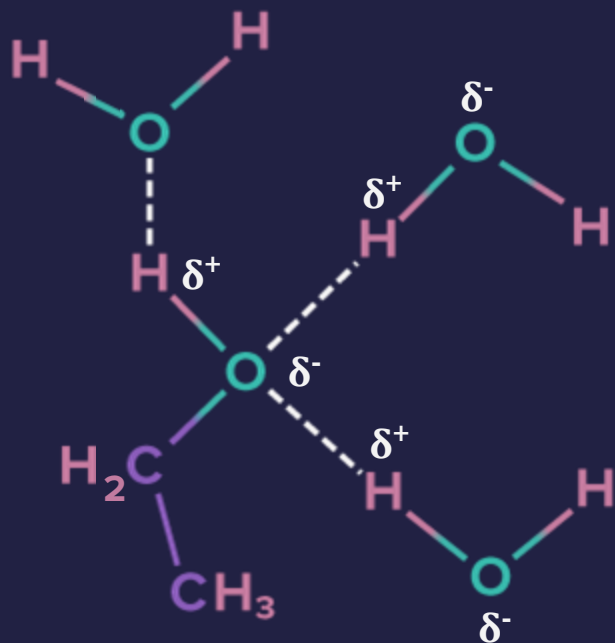


Water





Hetero Intermolecular H - Bonding



Alcohol in water





Conditions for the Formation of Intramolecular H - Bond

01

Ring formed as a result of
H bonding should be
planar

02

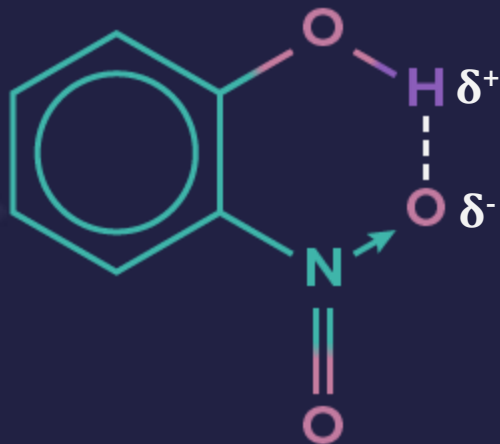
5 or 6 membered ring
should be formed

03

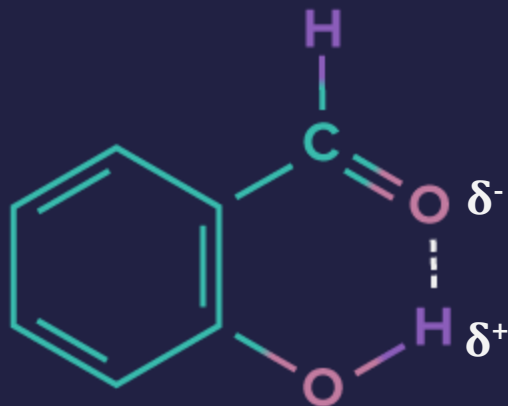
Minimum strain should be
there during the ring closure



Intramolecular H - Bonding



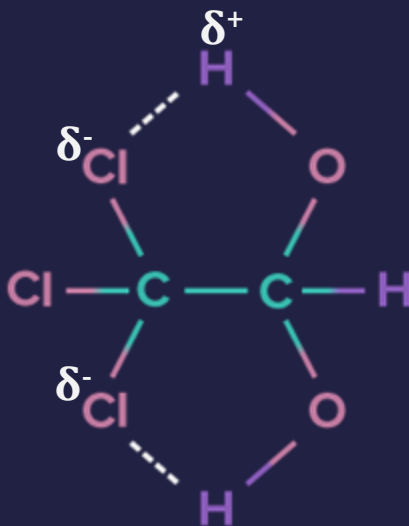
o-nitrophenol



Salicylaldehyde

Remember!!

Cl usually doesn't form H - bond due to their **low charge density**



Chloral hydrate ($\text{CCl}_3\text{CH}(\text{OH})_2$)



Effect of H - bonding on Physical Properties



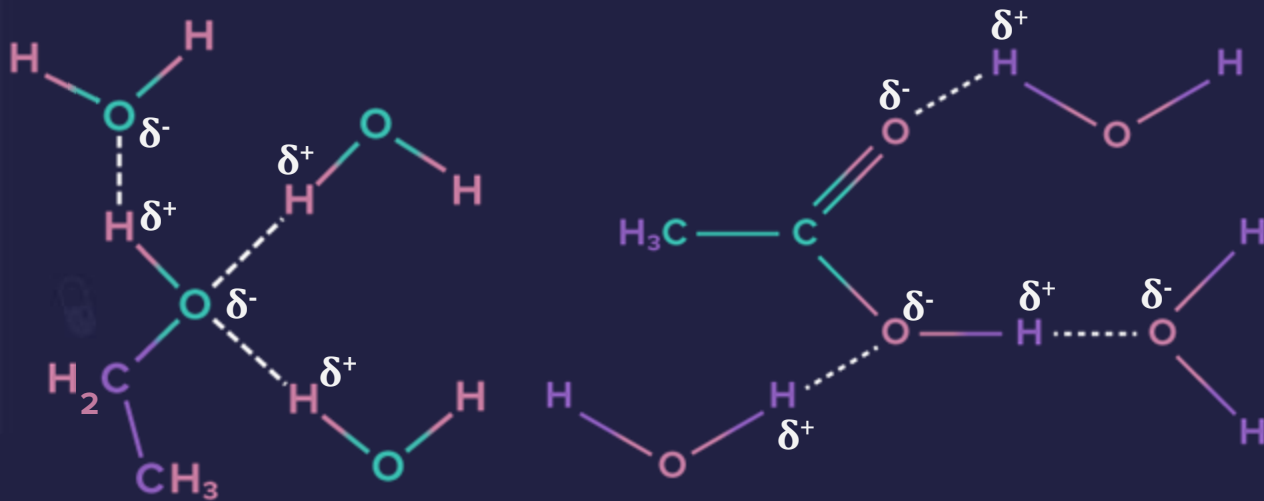
Solubility

Due to **intermolecular**
H-bonding

Solubility ↑

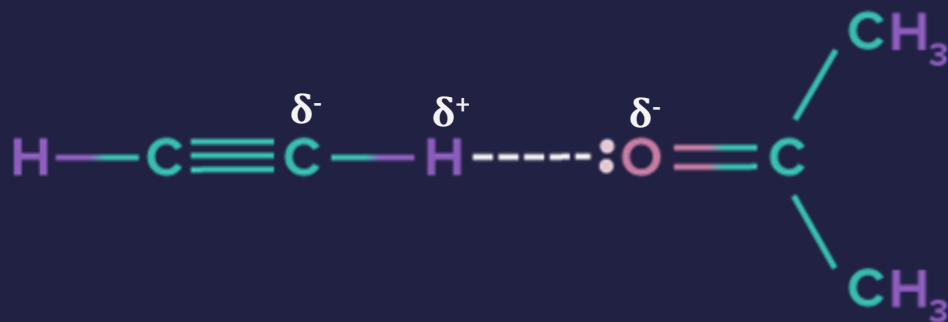
Few **organic compounds** are **soluble**
in water due to H-bonding

Alcohol,
Acetic acid etc.



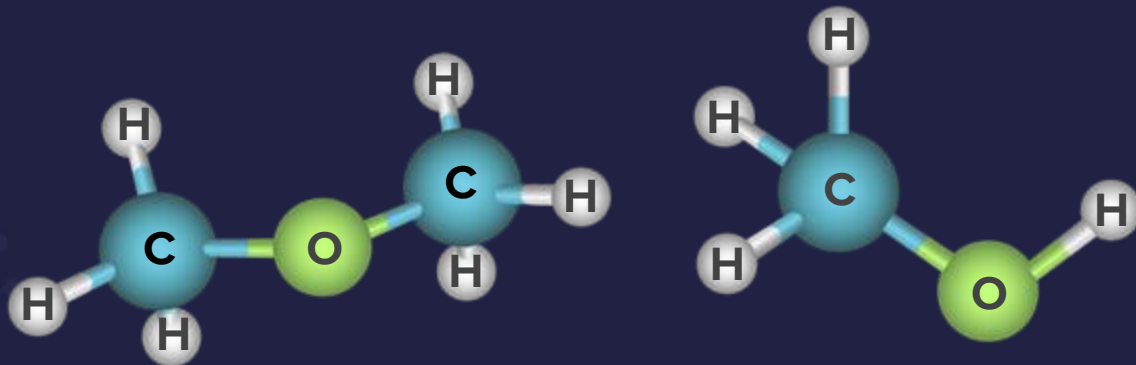
Solubility of Ethyne

C_2H_2 is highly **soluble in acetone** due to **H-bonding** but is not soluble in water



None of the above two has H-bonding individually

Solubility of Alcohols and Ethers



Solubility order

ROR

<

ROH

Example

CH_3OCH_3

<

CH_3OH



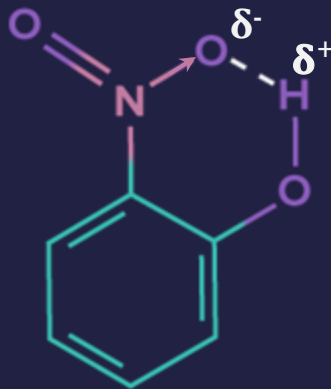


Solubility

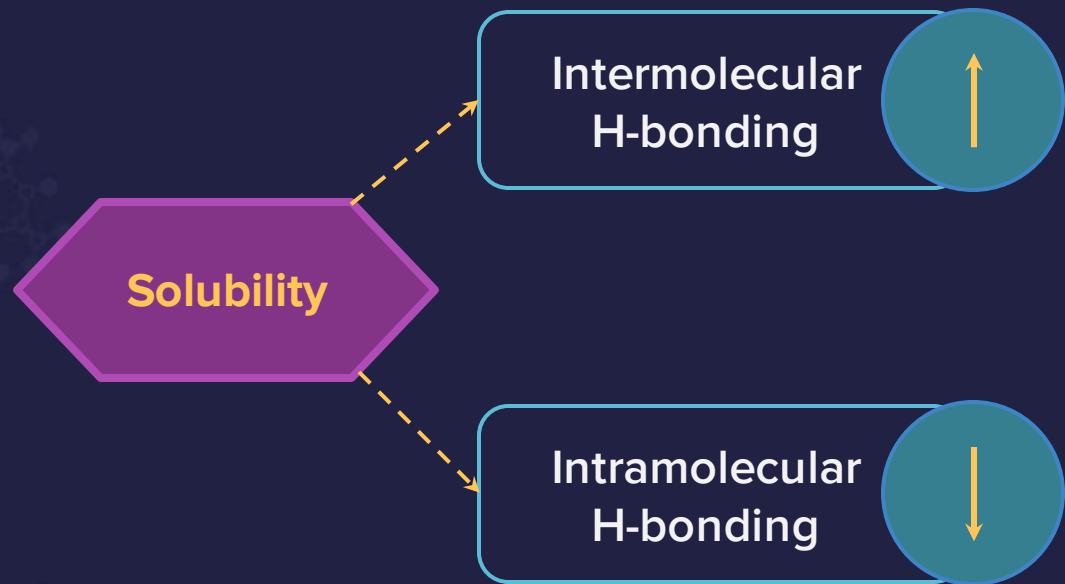
Due to **intramolecular** H-bonding

H is not available
for other molecule

Solubility ↓



Solubility

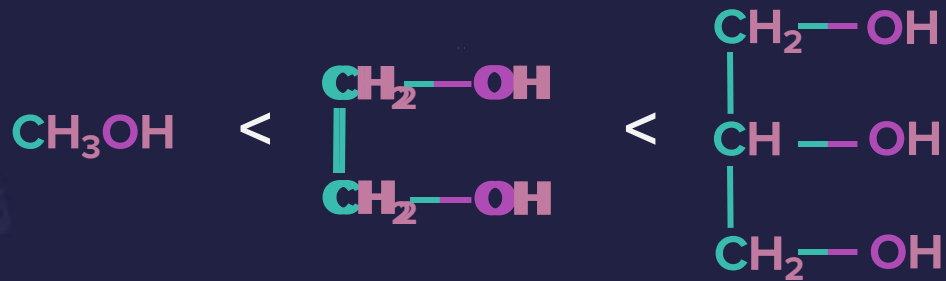


Viscosity

Hydrogen bond associates
molecules together

Viscosity ↑

Order of viscosity:





Boiling point

Intermolecular
H-bonding

Boiling point ↑

Intramolecular
H-bonding

Boiling point ↓





Order of Boiling point



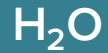
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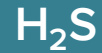
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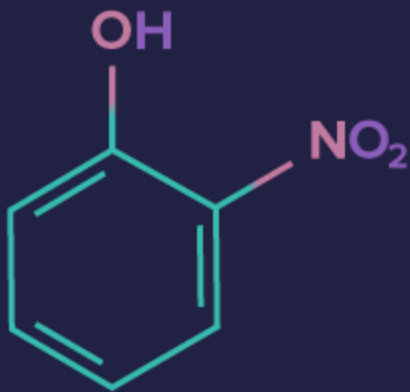


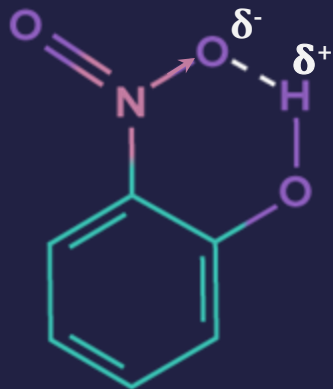
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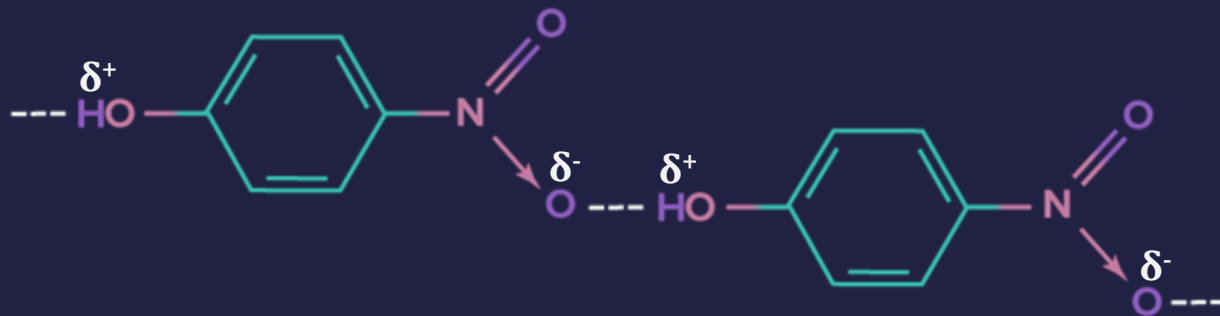


Which of the following molecules has higher boiling point?





o-Nitrophenol
(Intramolecular H - bonding)

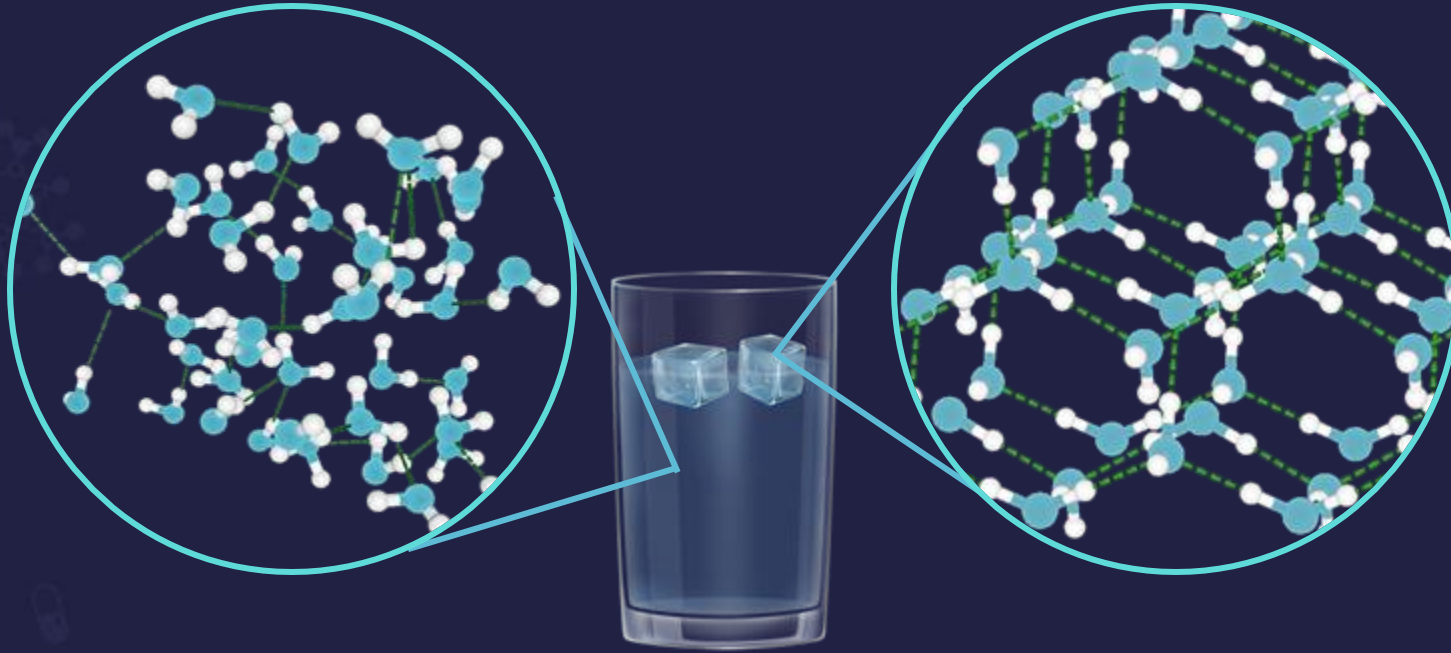


p-Nitrophenol
(Intermolecular H - bonding)





Why Does Ice Float Over Water?





Why Does Ice Float Over Water?

Extensive network of **H bonds**



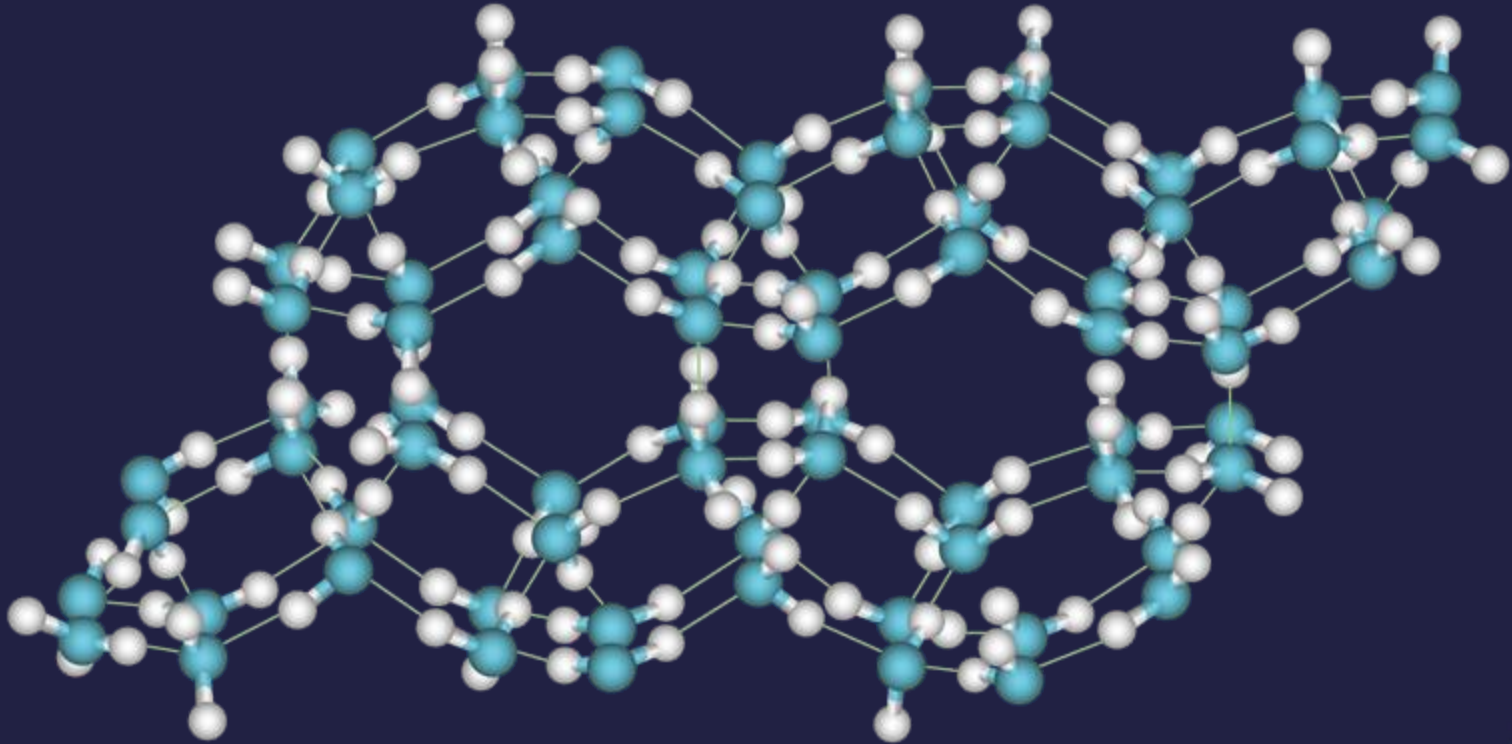
Ice has **cage like** structure
with vacant space



H₂O (s) is less dense than **H₂O (l)**

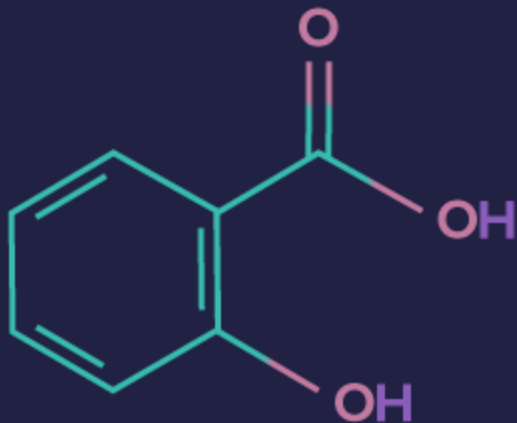


Why Does Ice Float Over Water?

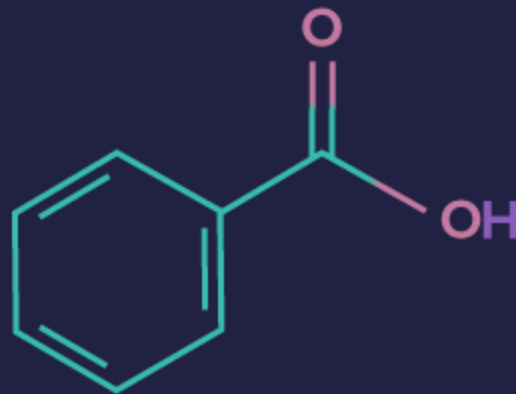




Which of the following molecules has the higher acidic strength?



A



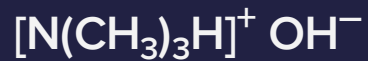
B





Out of the following molecules, which is a stronger base?

A



B





Which of the following are more viscous than water?

a) H_2SO_4 (l)

b) H_3PO_4 (l)

c) H_2O_2 (l)

d) HNO_3 (l)





Which of the following is/are correct?

- a) Boiling point of alcohol is higher than than of diethyl ether
- b) Density of water is higher than ice
- c) Glycerol is more viscous than ethanol
- d) Ammonia is more easily liquified than HCl due to bonding in NH_3





How many of the following has hydrogen bonding





Which of the following compounds can form H-bonding with each other?
[NEET 2002]

a) CH_3COOH and H_2O

b) Phenol and CH_4

c) Acetone and CHF_3

d) HF and PH_3





Which of the following is not true about H_2O molecule?
[NEET 2001]

- a) The molecule has $\mu = 0$
- b) The molecule can act as base
- c) Shows abnormally high boiling point in comparison to the hydrides of other elements of oxygen group
- d) The molecule has bent shape





Which of the following represents the correct order of strength of H-bond?
[NEET 2003]





Which of the following molecules is expected to exhibit intermolecular H-bonding?
[NEET 2000]

I) Acetic acid

II) o-nitrophenol

III) m-nitrophenol

IV) o-boric acid





Select correct alternate:

a) *I, II, III*

b) *I, II, IV*

c) *I, III, IV*

d) *II, III, IV*





Stay Positive. Work Hard. Make It Happen!

THANK YOU

