

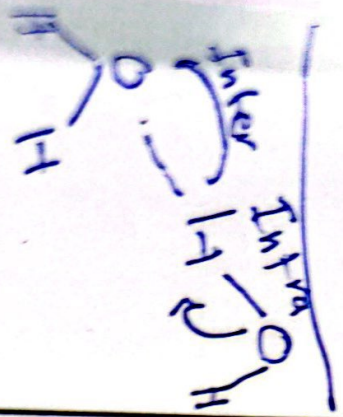
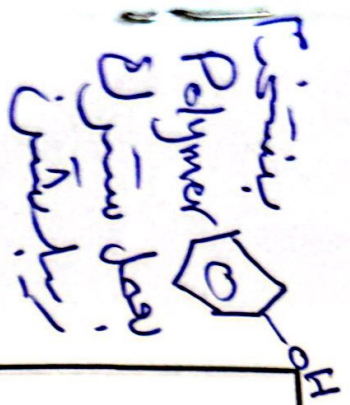
٢٠١٠/٣/١٤٤٥

(A) 34°C
B.P

(B) 72°C

(C) 101°C
B.P

Esra'a youself Malkawi



The Hashemite University
Faculty of Pharmaceutical Science

Physical Pharmacy I

Intermolecular forces

Credits: Dr. Nizar Al-Zoubi

Surface Tension

في الفيزياء الكيميائية مع تشرع الانجبية للدوا / التفاعلات كغيرها من العمل تشكيل

* الخصائص الفيزيوكيميائية مع تشارك الذائبة للدوا، التفاعلات وكثير عوامل العمل تتشكل للدوا.

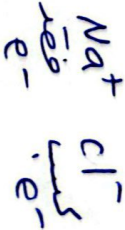
- بدأنا نعرف ليداهم بتدخل على ١٠٠ ليداهم بتدخل بزيوت

- الهم يتكون من جزئيات H_2O وترتبط مع جزيء آخر $H-O-H$ في الرابطة بين جزيئات

- لو عننا $NaCl$ تتكون رابطة **Intermolecular forces**

- Intermolecular Vs. Intramolecular forces.
- Intermolecular forces: between molecules (e.g. Van der waal forces)
- Intramolecular forces: inside the molecule, i.e., between atoms or groups inside the same molecule (e.g., covalent, ionic, and metallic).

حالة الاستقرار



حافظت الرابطة

لأنها عندها إلكترون

وامر مفا تقدر

ولاح عندها (٧) إلكترون

فاسم الرابطة تساهمية

- الرابطة التساهمية الذرات كل واحد شارك بالالكترون ريس عن الرابطة الإلكترونية

جائيت من نفس المصدر هاتين الرابطة اسعها تساهمية وزي نيكل مع CH_4

- الـ $Metallic$ يكون عننا $+ve$ شحنة لا Mg^{+2} يعني Mg^{+2} وبسبب ve - صورية زي e^- هو الهم

فالـ $Metallic$ بتوصل الهم باليسهل لانه بتشارك في طريق e^-

* الرابطة Intramolecular

صغيرة Intermolecular

جرا فصل Mg عن

الرابطة طاعة

البرصا زينة عن

فصل جزئيات الهم

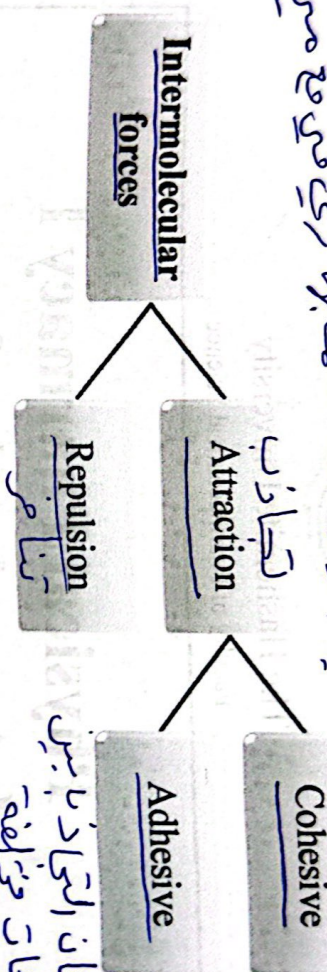
عن بعض

الرابطة Intramolecular

The key difference between the two types is that the covalency is not established in intermolecular interactions → less energy is required to break intermolecular forces as compared to intramolecular ones.

Intermolecular forces

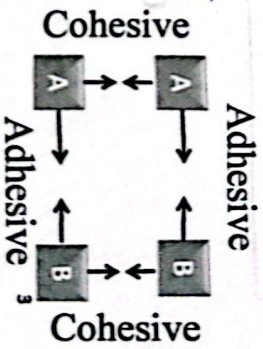
إذا كان الجاذب بين جزيئات متشابهة فهي تسمى Cohesive



إذا كان التجاذب بين جزيئات مختلفة Adhesive

Cohesive is the attraction of like molecules

Adhesive is the attraction of unlike molecules



جزيئات المتشابهة
تجاذب
A مع A
A مع B

Repulsive and Attractive Forces

- When two atoms or molecules are brought closer together, the opposite charges and binding forces in the two molecules are closer together than the similar charges and

فأنا إذا بقي أخذ ذرات الهيدروجين H_2 ويوصلها H_2 وسحبهم داخل الوعاء موجب وغازها سالب والرقص قد يتغير كالزرة H_2 غازا أنا بي الملح من electrostatic interaction نفسه الجزيء في نفسه فذلك يبعدهم لأنه على شحنات مختلفة ومتشابهة

Repulsive and Attractive Forces

-

4

3

Intermolecular forces

Intermolecular forces can be divided into:

- ① • Van der Waals forces
- ② • Ion-dipole interaction
- ③ • Ion-induced dipole interaction

*۔ کی تصوف کی جڑیں ۱-۵

- ④ • Ion-ion interaction
- ⑤ • Hydrogen bonds

Van der ingang

مجلس شورای اسلامی

nest 9050132

21/10/20

the $\text{C}-\text{H}$ bond length is lowest

٦- اصفى الصفا

١- فصل الاستقرار لها ٢٠ مبدئ

۱۔ اللہ اور ان کے پیغمبروں سے

- وضعه لاليزان اللى هي عند bond length

عارة الربطة تكون $A(3, -1)$ ← البعد 10.

30103/1440

negative charge

لا انتقلت بالحدود الى بلاد السودان الغربية

11

One of the atoms

One of the atoms in the covalent bond has the ability to attract the shared electrons to itself

resulting in a polar molecules

- Difference in the electronegativity
- dipole is a separation of two opposite

- dipole is a separation of two opposing charges over a distance r and generally described by a

vector $\vec{\mu} = q\vec{a}$ known as a dipole moment (μ)

- The ^{net} symmetry of the molecules affects generally its dipole moment $\delta^+ \text{H} - \text{Cl} \delta^-$



7

۱۔ میں دنیا و اہم میں فرق بالکھرو و بسے یعنی یکو نند ی Polar و کنا ز ا ب ی آلملح

کا جوہر سبز نیلوی
New Polar

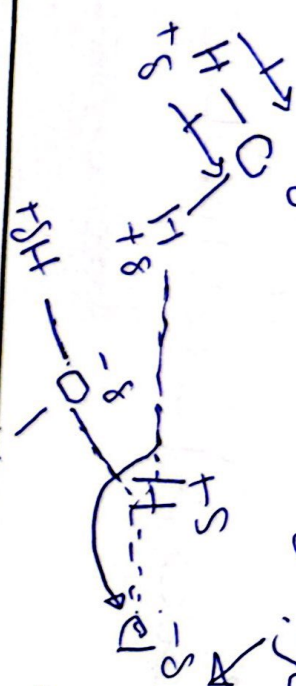
Handwritten notes in Arabic at the top right corner.

Van der Waals forces

• Van der Waal interactions are weak forces that involve the dispersion of charge across a molecule called a dipole.

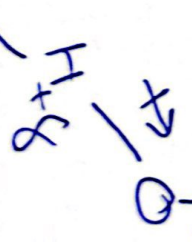
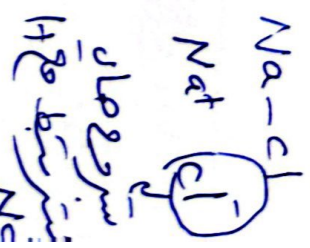
• Van der Waal interactions can be classified into:

- A. Dipole-dipole interaction, orientation effect, or Keesom force
- B. Dipole-induced dipole interaction, induction effect, or Debye force
- C. Induced dipole-induced dipole interaction, dispersion effect, or London force



dipole dip. interact

Handwritten Arabic notes below the title.



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Hydrogen Bond

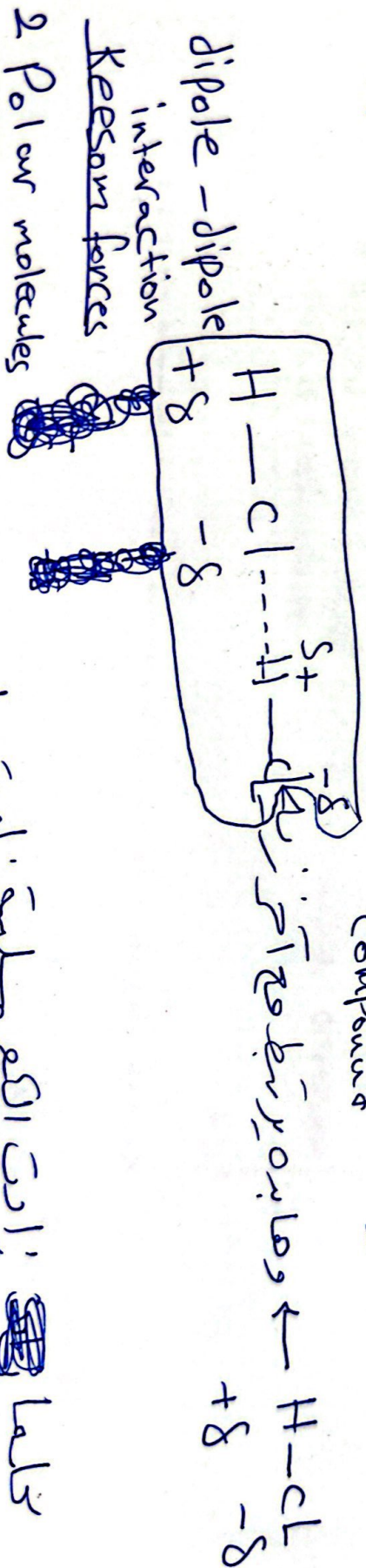
$\frac{1}{10}$

~~Edipale~~ Paleis met iken, 110, 15 jaar, van der
waals *

induced dipole in H_2O

dipole
London $\rightarrow$ induced $\rightarrow$ Debye

ال dipole لا يكون عندى Polar compound

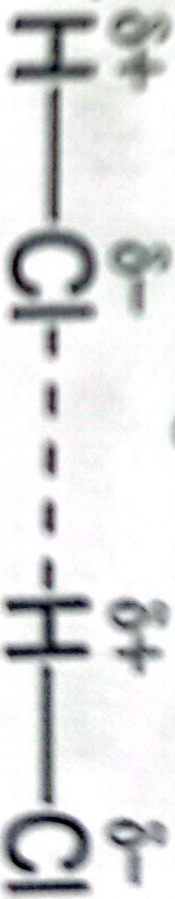


Polar molecules  
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Van der Waals forces

- The Partial opposite charges (permanent dipoles) attract one another (dipole-dipole interactions)
- Two polar molecules (two permanent dipoles)
- The dipole-dipole forces increases as the polarity of the molecule increases.

- Keesom forces are much weaker than ionic bonds because the charges involved in bonding are partial.



٢٠١٠/٣/١٤/٤٤٥

من القوى كeesom أو Ionic ؟
التي لا يكون في قوى كeesom
التي لا يكون في قوى كeesom

Partial Charge
التي لا يكون في قوى كeesom

Van der Waals forces

- Keesom forces occur between polar molecules in which the permanent dipoles interact with one another (dipole-dipole interactions) or (orientation effect).
التي لا يكون في قوى كeesom
- Polar molecules have polar covalent bonds which are unevenly distributed in space due to the difference in the electronegativity of the atoms forming the bond e.g. HCl.
- The nucleus of the chlorine atom pulls the electron pair involved in the chlorine-hydrogen bond closer to itself and creates a permanent partial positive charge on the hydrogen and a permanent partial negative charge on the chlorine (Permanent dipole),
التي لا يكون في قوى كeesom

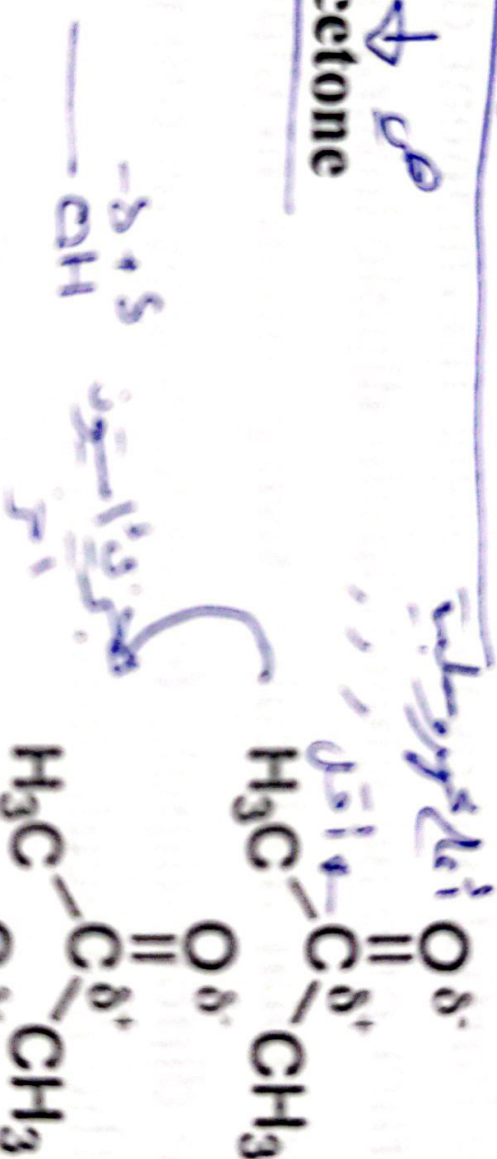


Dipole Moment has a
Magnitude and a Direction

Van der Waals forces

- Example of Keesom forces

- Acetone



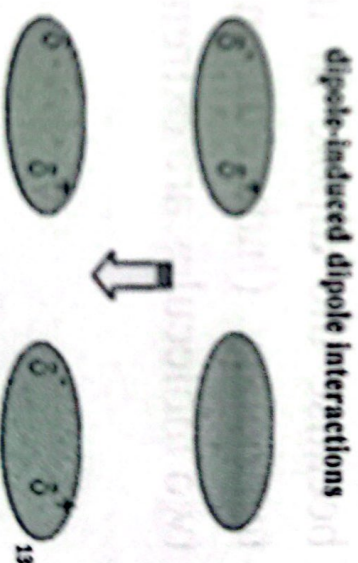
type of $\delta^+ \text{H}$ Hydrogen
dipole-dipole

interaction.

Van der Waals forces

another type

- Debye forces occur between a polar and a nonpolar molecule in which the permanent dipole in the polar molecule induce an electric dipole in the non polar one (dipole-induced dipole interactions) or (induction effect) e.g. water and oxygen.



الـ Debye forces تحدث بين الجزيئات القطبية والجزيئات غير القطبية

Induced dipole

ظاهرة حيث أن الجزيء غير القطبي يصبح قطبيًا مؤقتًا

* Polarized
شحنة (+) دائمة جزئية
وسالبة

* وجودها

الـ Polarized

مركبة حادثة

شحنة أو اللينة

موزعة بشكل

homogeneous

الإلكترونات

فإننا عندئذٍ نجد

الـ Polarized

في يمين الترتيب للإلكترونات

الـ Debye

القطب dipole مع تغير من الترتيب للإلكترونات في الجزيء -ve +ve

هذا لا يعني ربح ربح كوني ديبول

* فالسائل جاذباً مهماً بينهم

Van der Waals forces

- The oxygen molecule is nonpolar. However, when it comes close to the oxygen atom in a water molecule, the partial negative charge on the oxygen atom repels the electrons in the oxygen molecule. This causes (induces) a temporary partial positive charge in the end closest to the water molecule and a buildup of a partial negative charge in the end furthest away. This induced dipole is temporary and forms only when the two molecules are extremely close to one another.



Polarizability

Induction

القطب المؤقت
لأنه قريب
من جزيء الماء
القطب الدائم

dipole - induc
dipole
القطب المؤقت

أولاً إلى Full Charge
الجزئية الإلكترونية
أي قوى الأيونية
٣٠/٠٣/١٤٤٤هـ

Van der Waals forces

* The strength of Debye forces increases with the ease of distortion of the electron cloud of the nonpolar molecule (i.e. polarizability of the molecule).

- Debye forces is weaker than Keesom forces because the dipole in the nonpolar molecule is temporary (induced) and forms only when the two molecules are extremely close to each other.

two molecules are extremely close

15

جداً ضعيفه

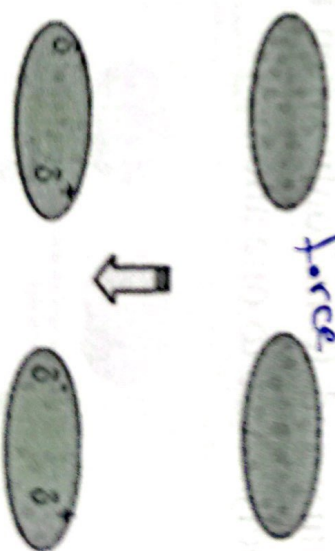
non polar متعادل
وكمسان جزئيه مثله

التي بغير لونه
الزهره ورج نقره
حوالهم

Van der Waals forces

• London forces occur between two nonpolar (neutral) molecules in which molecules can induce polarity on each other (induced dipole-induced dipole interactions) or dispersion effect). e.g. Helium, Neon, hydrocarbons...

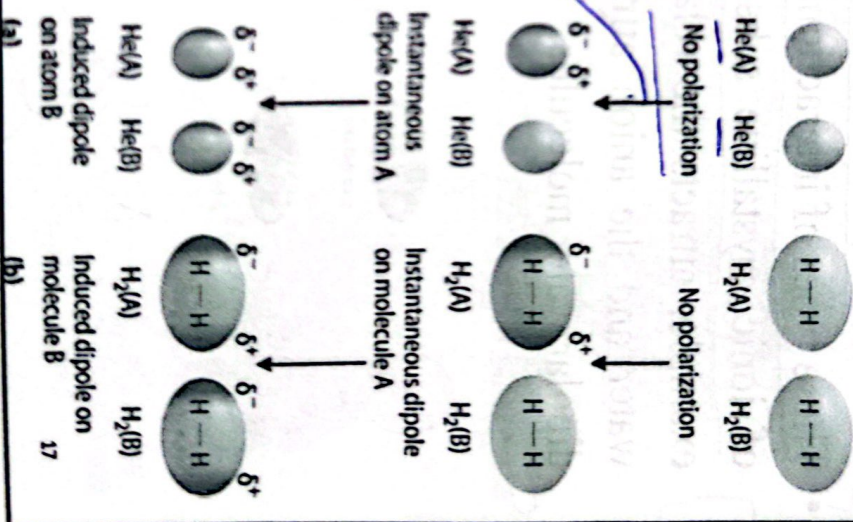
لندن
force
مما ياتي لندن



16

Van der Waals forces

- This attraction is produced by temporary asymmetry in the distribution of the electrons around the nucleus.



لندن

هذا هو التوزيع غير المتماثل للإلكترونات حول النواة
وهو ينتج عن التفاعل بين الشحنات

تفاعل اقراص الجزيئية
 $V_{\text{London}} + V_{\text{dipole-dipole}} + V_{\text{hydrogen bonding}}$

Van der Waals forces

- London forces occur between all atoms and molecules (between polar/polar and polar/nonpolar molecules as well)
- The larger the atom or molecule, the greater its polarizability (easier to induce a momentary dipole) and the stronger the dispersion forces become.
- This is because:
 1. The electrons are farther from the positive nucleus and so are held less strongly.
 2. The number of electrons is greater
- London Force is the weakest of all the intermolecular forces.

18

كلما زاد الحجم، يسهل أن يغير الإلكترونات مكانها
 فالقوى التشتتية London forces

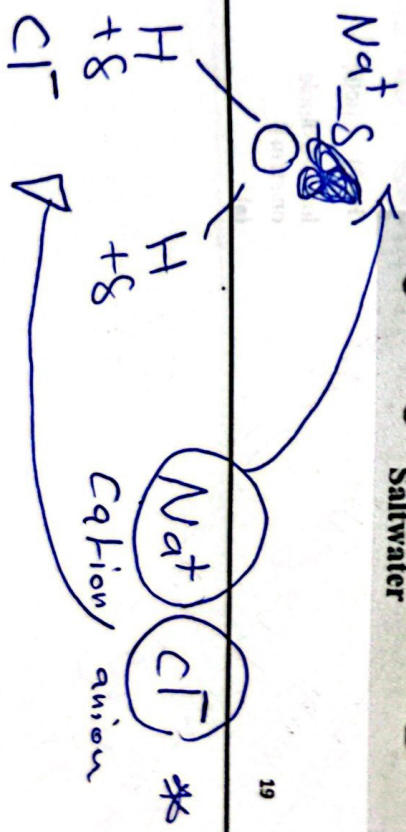
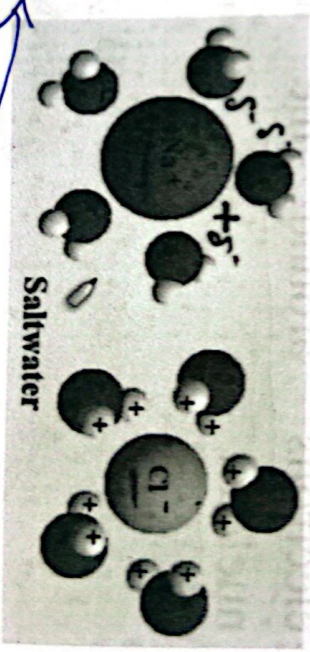
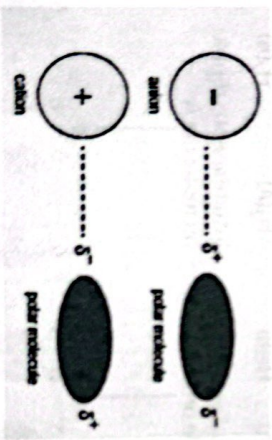
كلما زاد
 الذرة
 بزر القابلية
 بزرية
 تشتتية
 قوى التشتت
 الترابط

كلما زاد عدد
 إلكترونات الجزيء
 London forces

نوع
 NaCl $\delta^- \delta^+$
 مذيب و مذوب
 Solvent & Solute

* Ion-dipole forces

These types of interactions account in part for the solubility of ionic crystalline substances in water; the cation, for example, attracts the relatively negative oxygen atom of water and the anion attracts the hydrogen atoms of the dipolar water molecules.





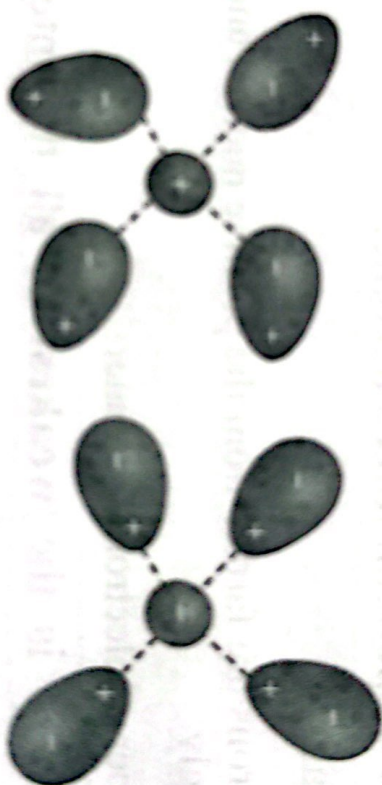
* Ion dipole
 interaction

dipole-dipole
 interaction

* كلاله شحنة
 جزيئات
 المترابطة اقوى

Ion-dipole forces

- Ion-dipole forces occur between a charged ion and a polar molecule (i.e. a molecule with a dipole). Cations are attracted to the negative end of a dipole, while anions are attracted to the positive end of a dipole.



Cation-dipole attractions

Anion-dipole attractions

1.5/1440

* Ion-Induced dipole

- Ion-Induced dipole forces occur between a charged ion and a nonpolar molecule.
- These forces result when the approach of an ion induces a dipole in an atom or in a nonpolar molecule by disturbing the arrangement of electrons
- Ion-induced dipole forces are presumably involved in the formation of the iodide complex
- $I_2 + K + I^- = [K + I_3^-]$



Spherical atom with no dipole.
The dot indicates the location of the nucleus.



Upon approach of a charged ion, electrons in the atom respond and the atom develops a dipole.

21





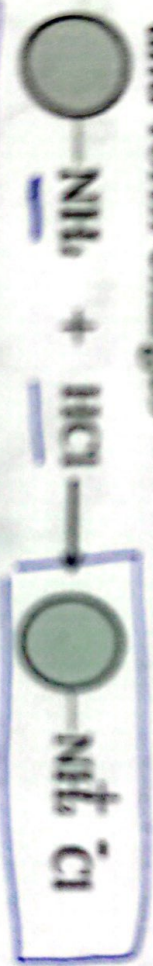
Ion-ion interactions

→ جزيئات
molecules

- A cation on one compound will interact with an anion of another compound (we are not talking about atoms)



-Uncharged molecules that will react upon interaction and form charges



* Ion-ion interactions may be intermolecular (e.g. a hydrochloride salt of a drug) or intramolecular (e.g. a salt bridge interaction between counter ions in proteins).

نوف
[NaF]

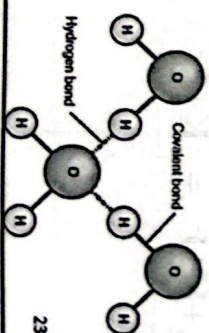
احفظهم باسم

[O/F/N]

ذرات
هذه

Hydrogen bond

- Hydrogen bond is a strong type of dipole-dipole interaction that occurs between a molecule containing a hydrogen atom and a strongly electronegative atom such as fluorine, oxygen, or nitrogen
- In order to create the bond, the hydrogen atom must be covalently attached to another electronegative atom.
- A perfect example of hydrogen bond is water.
- Hydrogen bonds can also exist between alcohol molecules, carboxylic acids, aldehydes, and DNA and polypeptides.



23

$C \infty H$

المائيس
dipole
dipole
dipole

B.p
Boiling point
Hydrogen Bond
ضعف على الكهروستاتيكية

Hydrogen bond

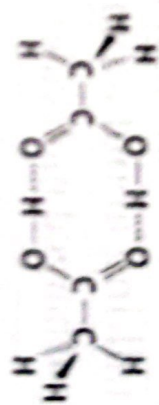
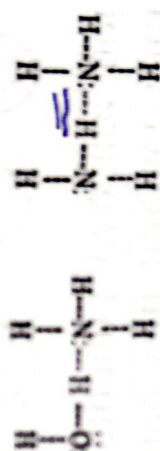
dipole-القطب
dipole القطب

القطب

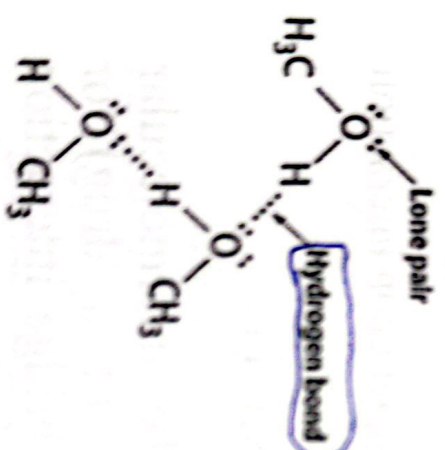
B.P Boiling point
Hydrogen Bond
القطب

Hydrogen bond

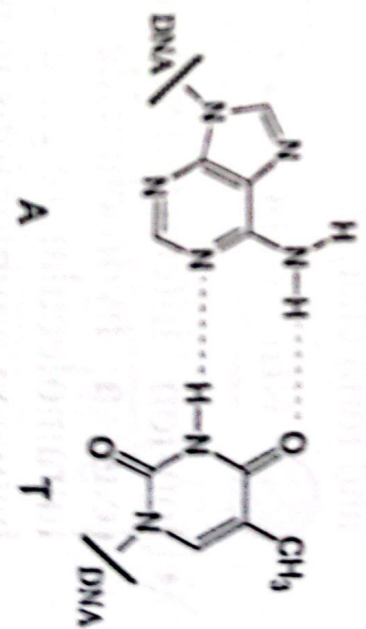
Examples



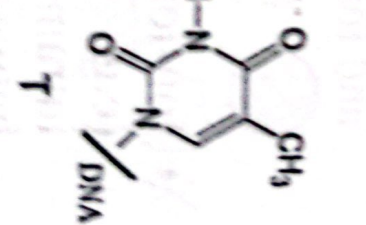
Hydrogen bonding in acetic acid



Hydrogen bonding in methanol



A



T

Hydrogen bond

- Hydrogen bonds are responsible for many unusual physical properties of water including its abnormally low vapor pressure, high boiling point, and the greater volume of ice water.
- Hydrogen bonding is stronger than all Van der Waals intermolecular forces (they are given their own classification), but are still weaker than ionic and covalent bonds.

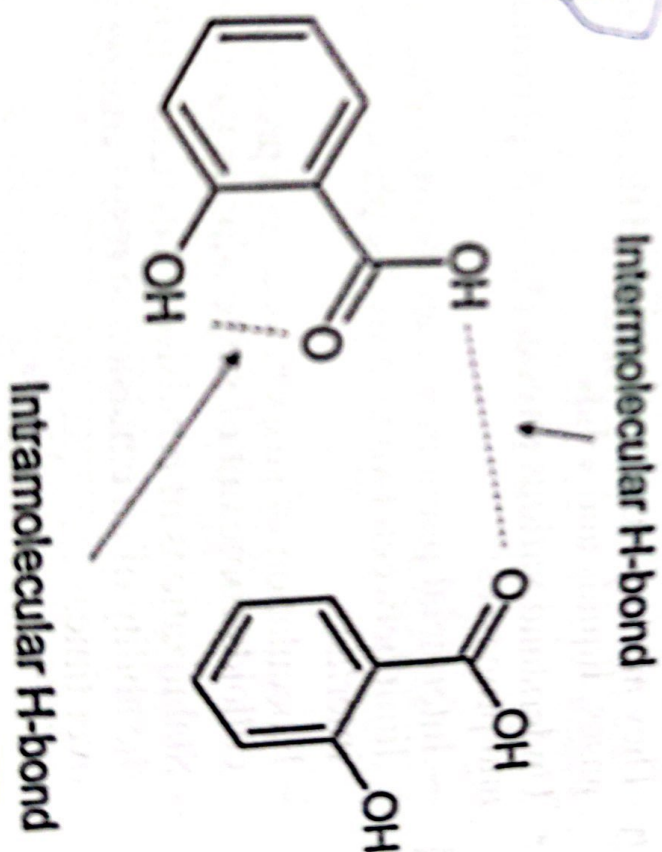
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حفظ الله روحه الكريم

Hydrogen is δ in $\text{C}=\text{O}$ & δ in $\text{O}-\text{H}$

25

Salicylic acid



26

Intramolecular
H-Bond

الرابطة التساهمية
الرابطة الأيونية

Bond energies

مقياس قوة الرابطة

- Bond energy is a measure of the strength of bond.

Intramolecular forces: ionic > covalent > metallic

Intermolecular forces:

- Ion-dipole > ion-induced dipole > hydrogen bond > Keesom > Debye > London

London

*Importance of intermolecular forces

- These forces govern the interactions between all kinds of matter (e.g., atoms, molecules, bulk)
- They are important to understand the properties of gases, liquids and solids.
- Understand various physicochemical phenomenon and processes:

- Interfacial phenomena: are the ones that occur at the limit between two immiscible phases, so-called surface or interface.
- Flocculation of suspensions: is a process wherein colloids come out of suspension in the form of floc or flake.
- Stabilizations of emulsions, Emulsion stability refers to the ability of an emulsion to resist change in its properties over time.

* حریم غزالها نرعا الکسبولة اولها بری

اعلقت اشي دامل اشي ازا فست تفاعل رخصا

28

جسارفة الطارة

لها ابييت حلي واطة

بشار ضروري برخل

الملاسة للاطارة

Surface
Tension
رعي

Solid
Powder
حالة

والروا دهاد

Interaction مع

التي لها خط كل

الملاسة رعي برخل

* بالمنعط مجرد حافة ليست المنعط حصة

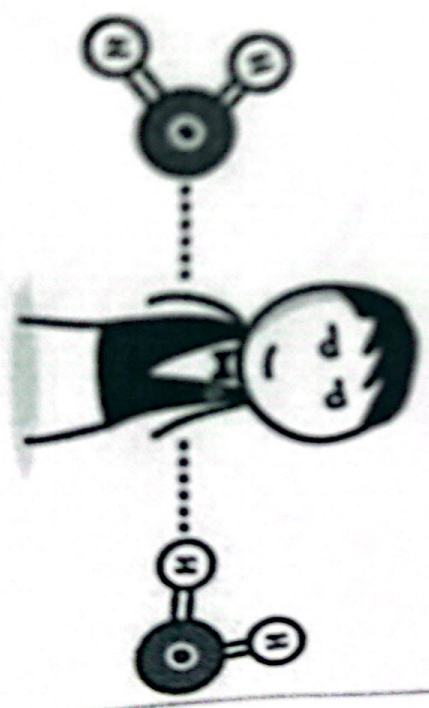
تفاعل رعي ينفكل

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- Compaction of powders in capsules.
 - Dispersions of powders or liquid droplets in aerosols
(An aerosol is a colloid of fine solid particles or liquid droplets, in air or another gas).
 - Compression of granules to form tablets.
 - From a biotechnology point of view:
 - Various intermolecular and intramolecular forces govern the secondary, tertiary and quaternary structures of biomolecules (e.g., proteins, DNA, RNA).
 - They influence the stability, formulation and storage of pharmaceutical product derived from such biomolecules.

...received from such biomolecules.

Thank you

THE NAME'S BOND,



HYDROGEN BOND