



The Hashemite University
Faculty of Pharmaceutical Science

Physical Pharmacy I

Lecture 1: Intermolecular forces

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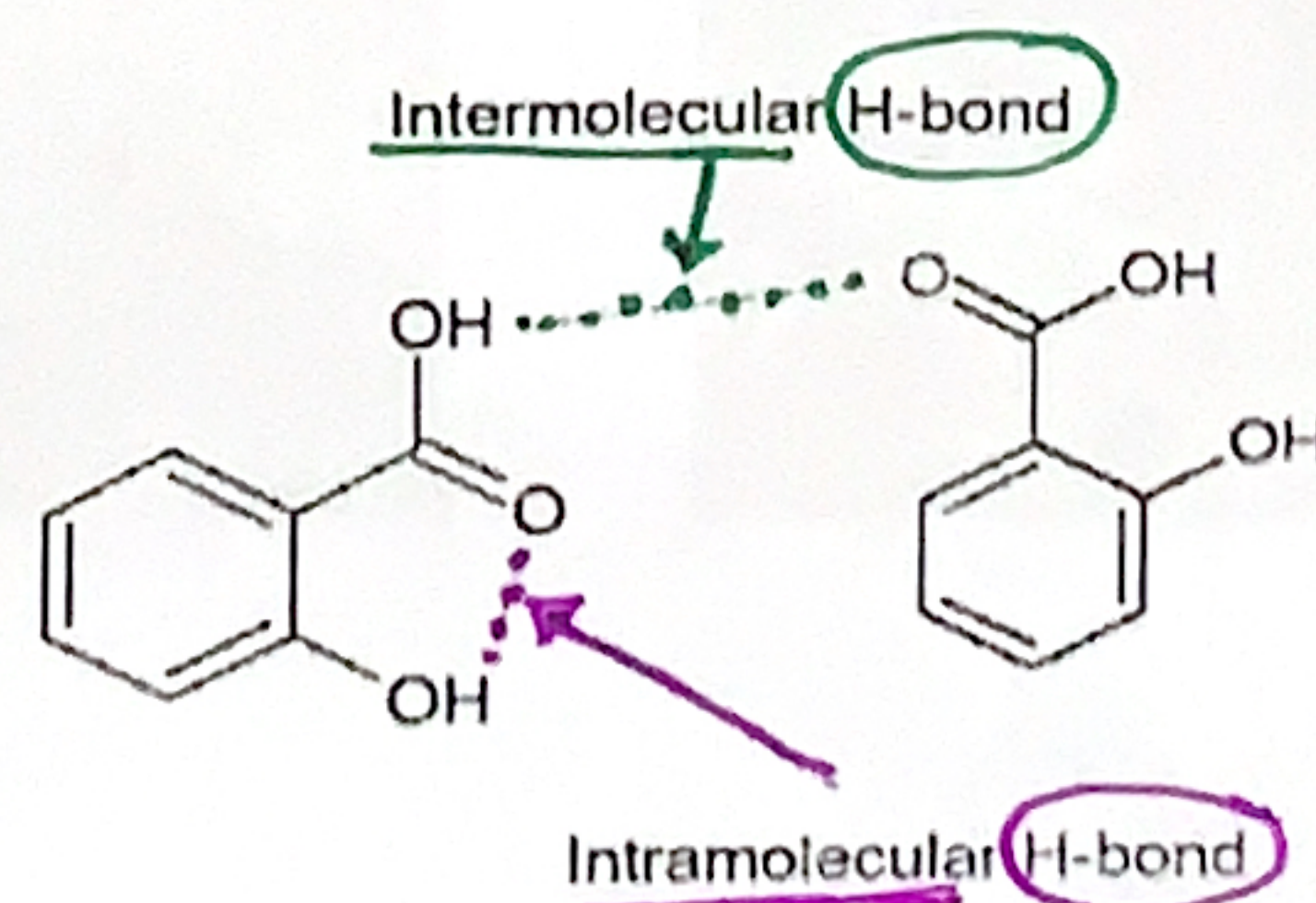
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Intermolecular forces

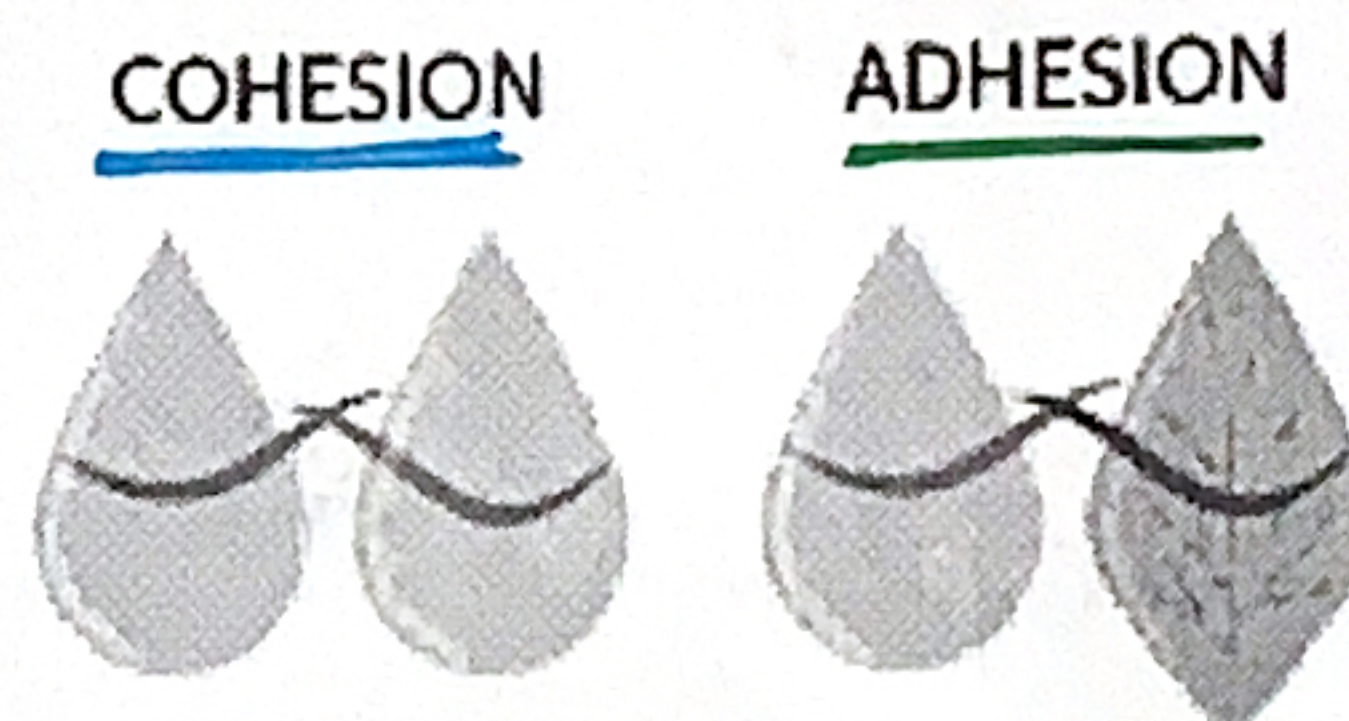
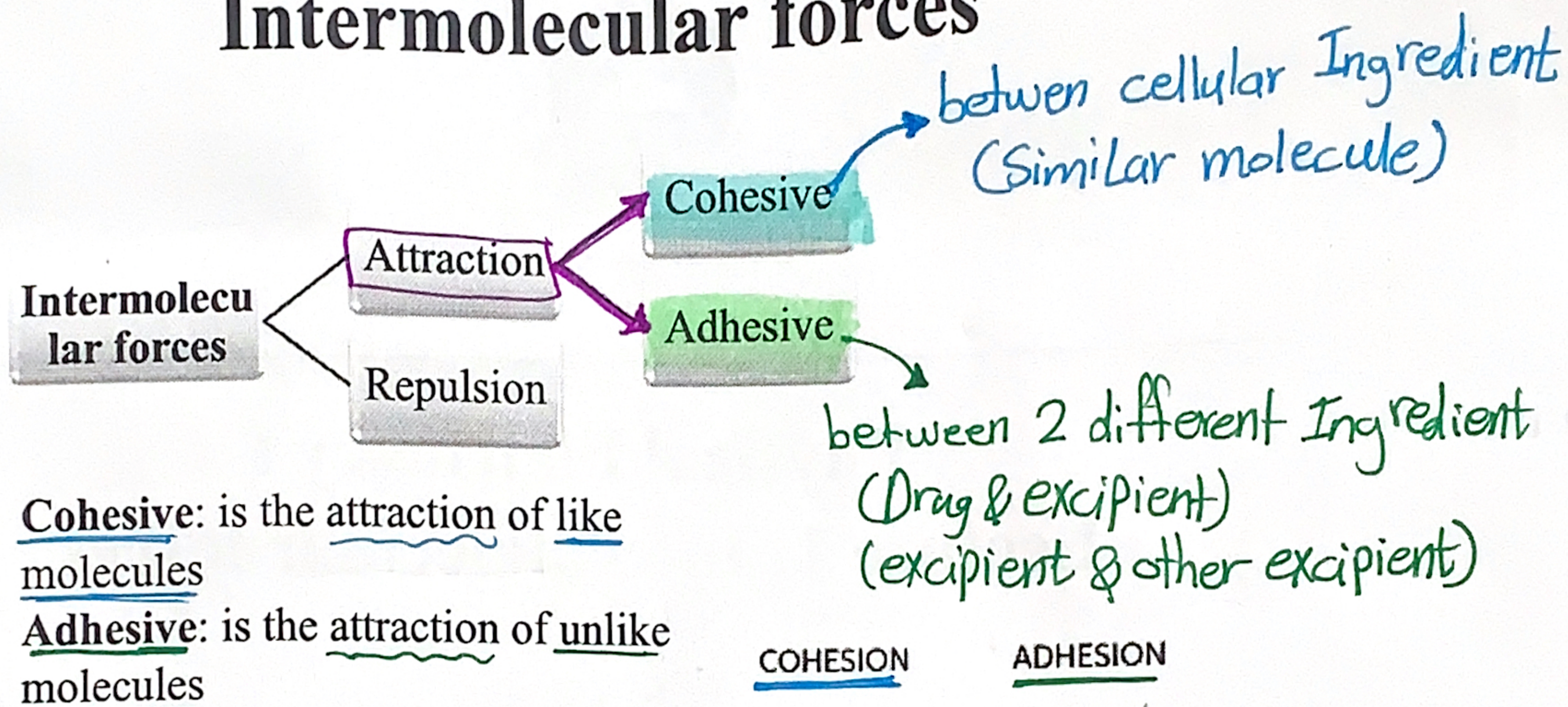
- Intermolecular Vs. Intramolecular forces.
- Intermolecular forces: between molecules (e.g. Van der waal forces).
- Intramolecular forces: inside the molecule, i.e., between atoms or groups inside the same molecule (e.g., covalent, ionic, and metallic).

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.

Salicylic acid



Intermolecular forces



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Repulsive and Attractive Forces

Different charge
= Attraction.

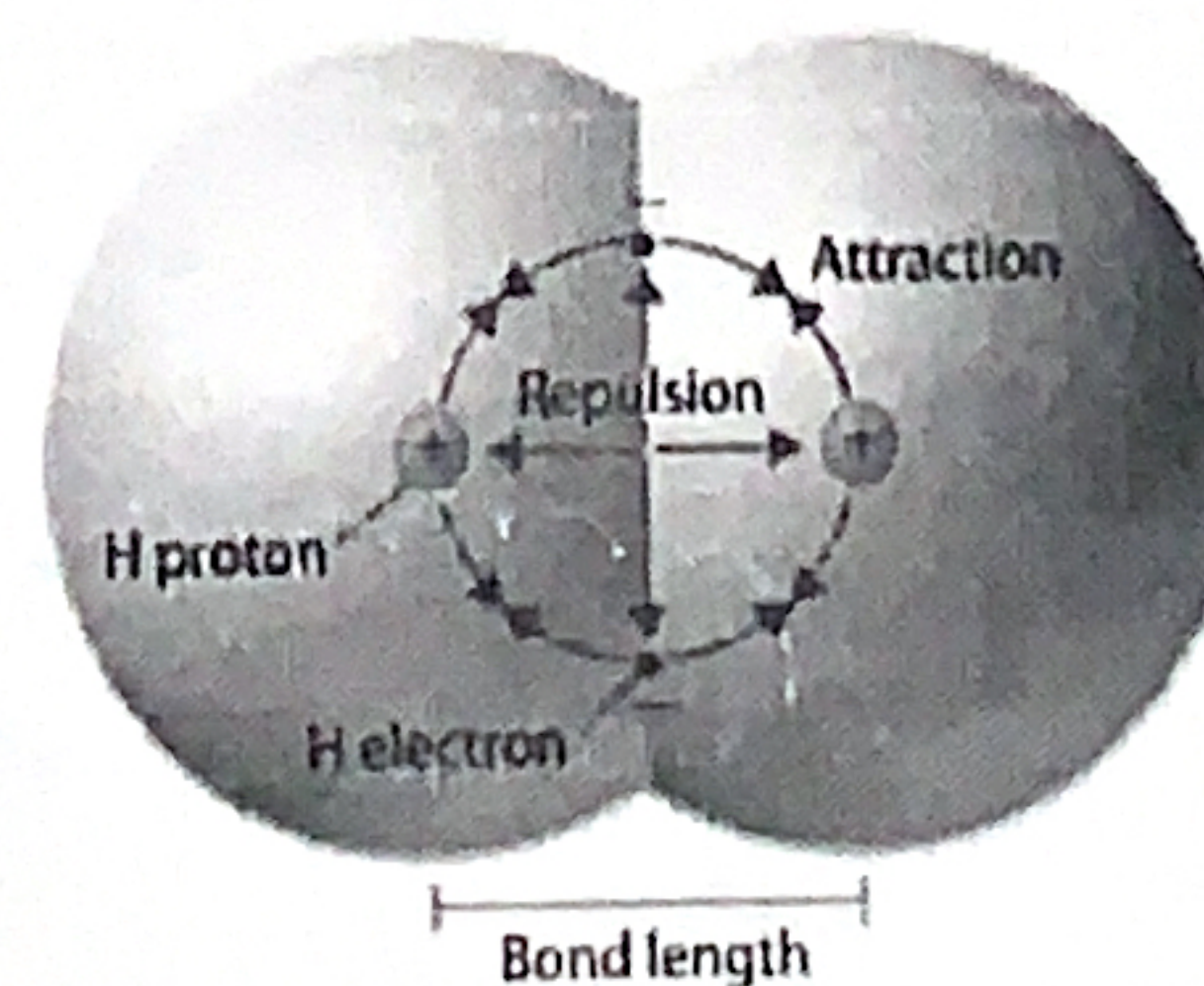
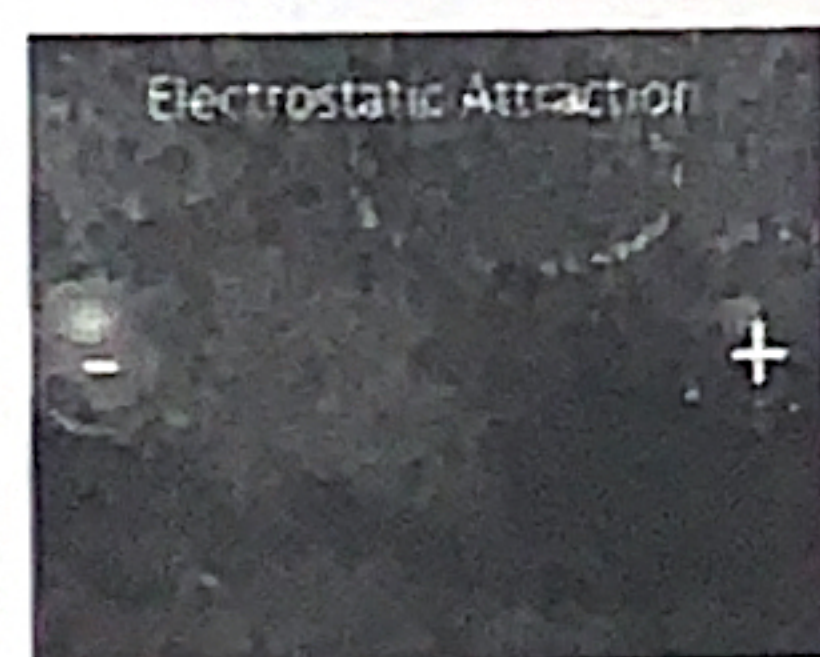
Similar charges
= repulsion

قاعدة: ال energy
الى بسحيم بكمشي
بالحياة ولازم ال energy
تنزل لأقل إشي أو صفر
عشان يصير stable

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 forces, causing the molecules to attract one another.

When the molecules are brought so close that the similar charges touch, they repel each other (like rigid elastic bodies).

At a certain equilibrium distance, (about 3–4 Å), the repulsive and attractive forces are equal. At this position, the potential energy of the two molecules is a minimum and the system is most stable.

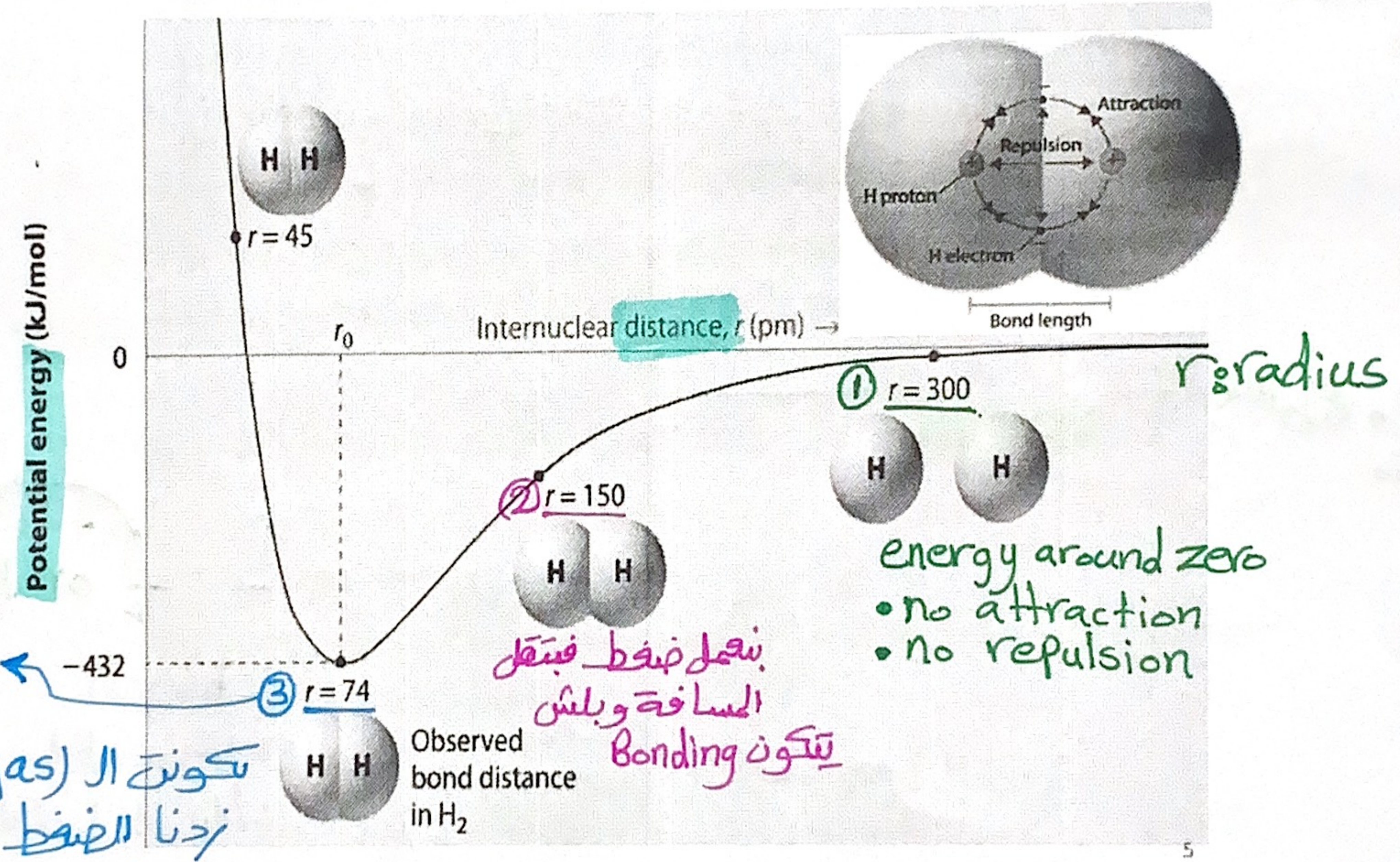


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Repulsive and Attractive Forces

- * To break the Bond we need energy.
- * To make the Bond we release energy.

10/8/2022



Intermolecular forces

Intermolecular forces can be divided into:

- Van der Waals forces
- Ion-dipole interaction
- Ion-induced dipole interaction
- Ion-ion interaction
- Hydrogen bonds

Ion: full charge eg: $NaCl$ (full charge) (Na^{+1} / Cl^{-1})
 *water $\rightarrow$ hydrogen is partial Positive.

دائماً لما يكون عننا 2 atoms لازم وحدة منهم تكون more electronegative than other

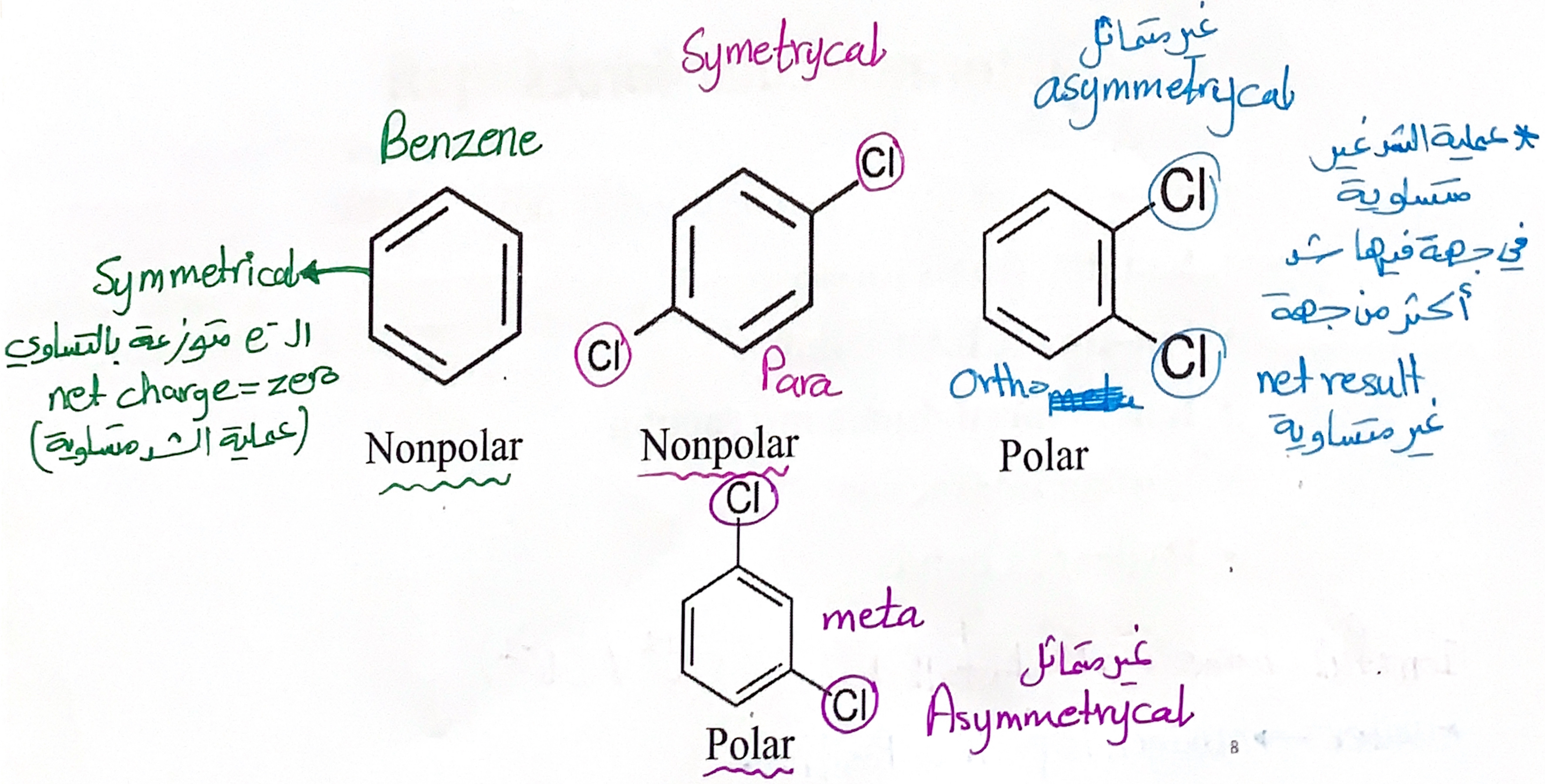
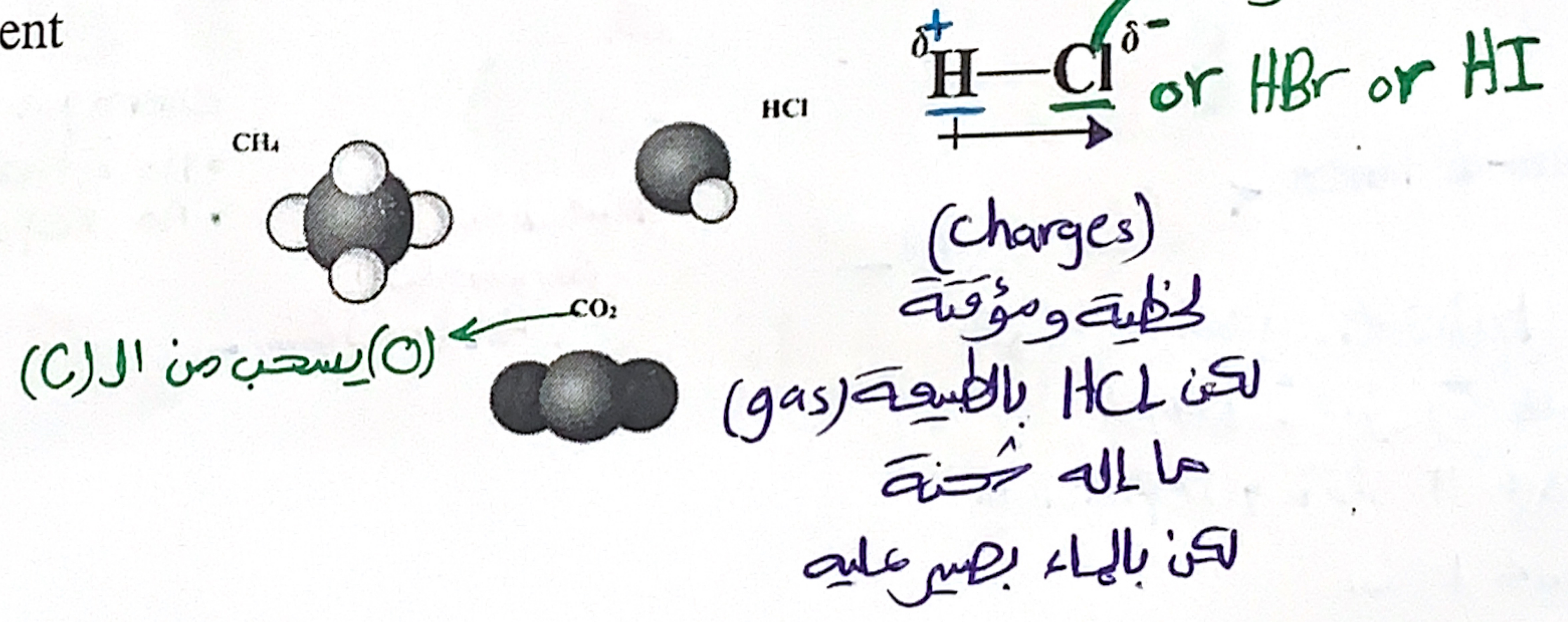
قطب: Pole Polarity

- One of the atom in the covalent bond has the ability to attract the shared electrons to itself resulting in a polar molecules
- Difference in the electronegativity $\delta^+ \rightarrow \delta^-$
- dipole is a separation of two opposing charges over a distance r and generally described by a vector known as a dipole moment (μ).

التوزيع واتجاه الـ e^- متماثل

The symmetry of the molecules affects generally its dipole moment

بسحب الـ e^- نحوه



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

← تغير لحظي (تأثير مؤقت)

* Dipole: net result and charges Positive, Negative.

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.

← بنزید الـ Polarity
كما أنه تزيد الـ (En)
electronegativity
طرا بـ ←
أو بتزید العدد

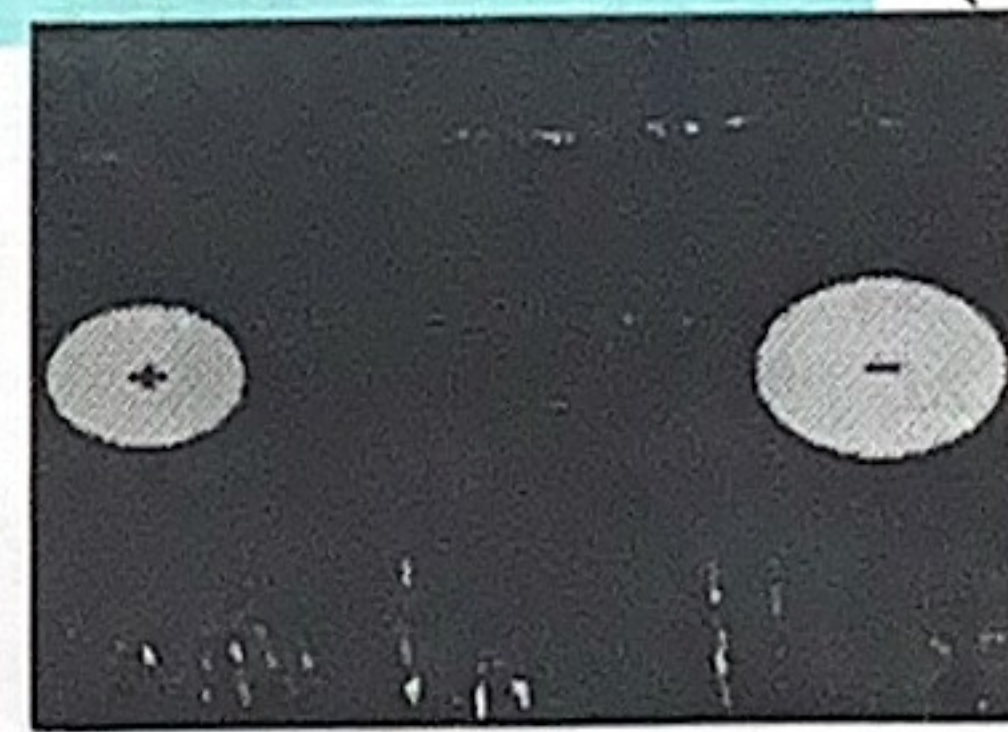
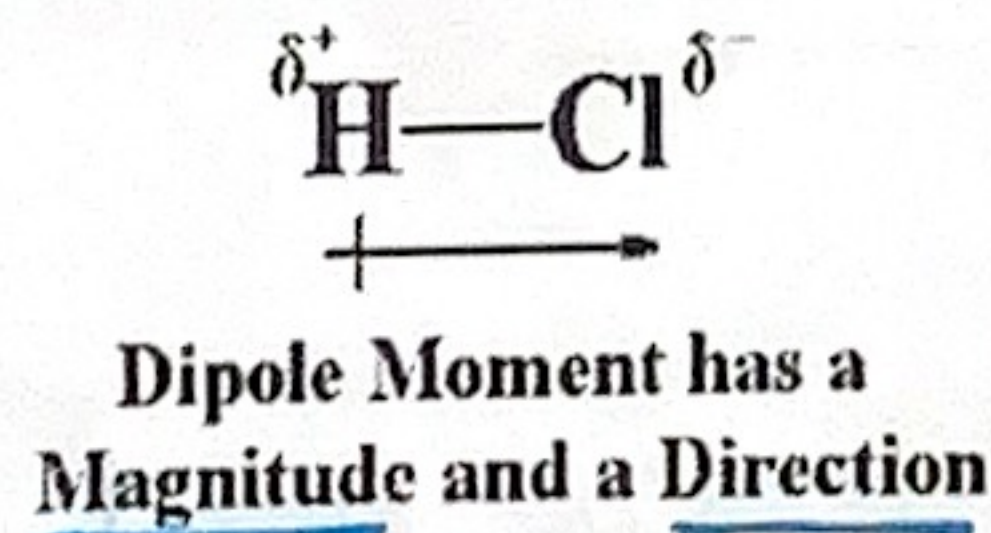


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(Covalent not Ionic)

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).
- 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)

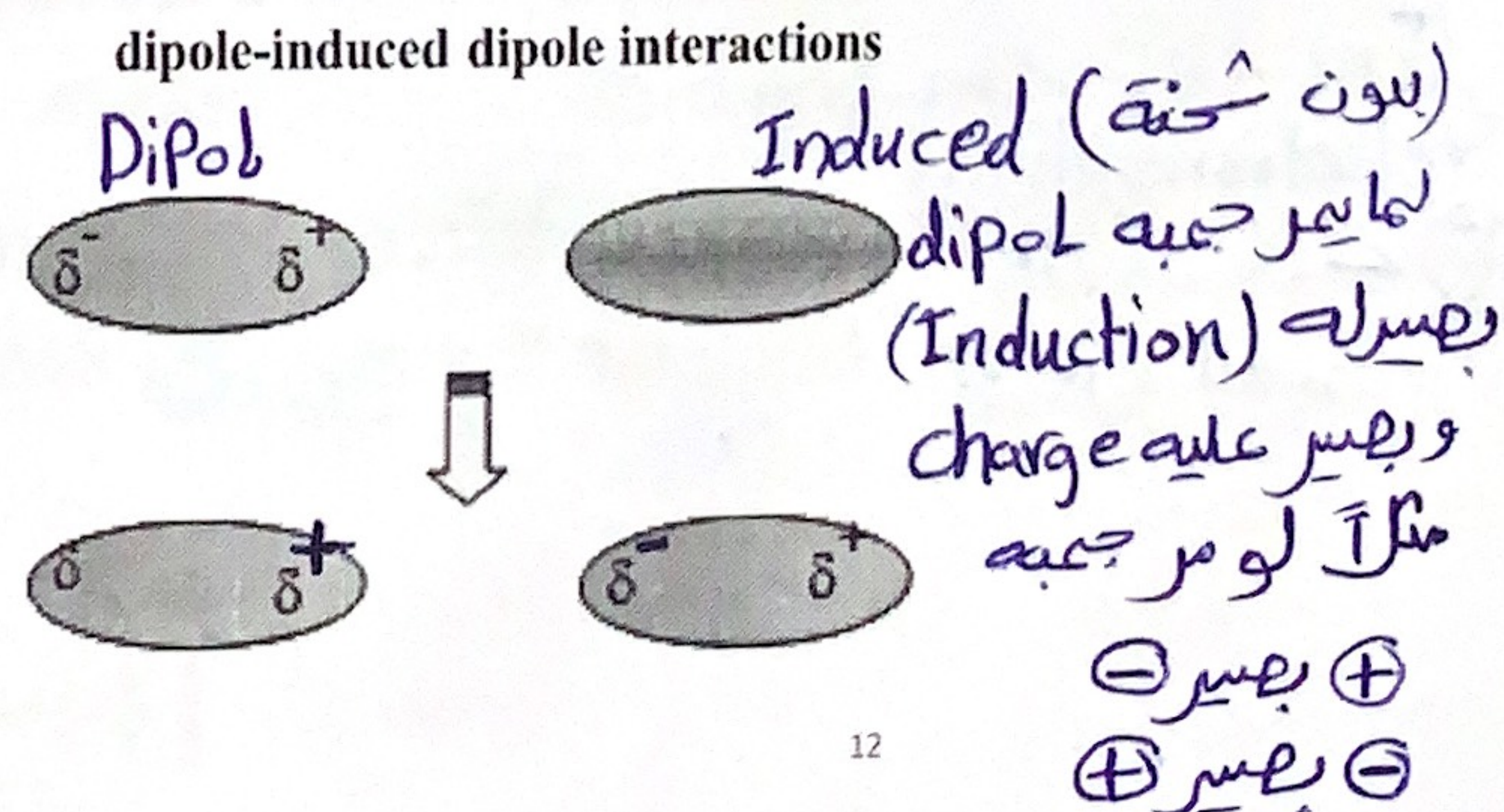


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Van der Waals forces

واحد Dipole والآخر Induced

- 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.



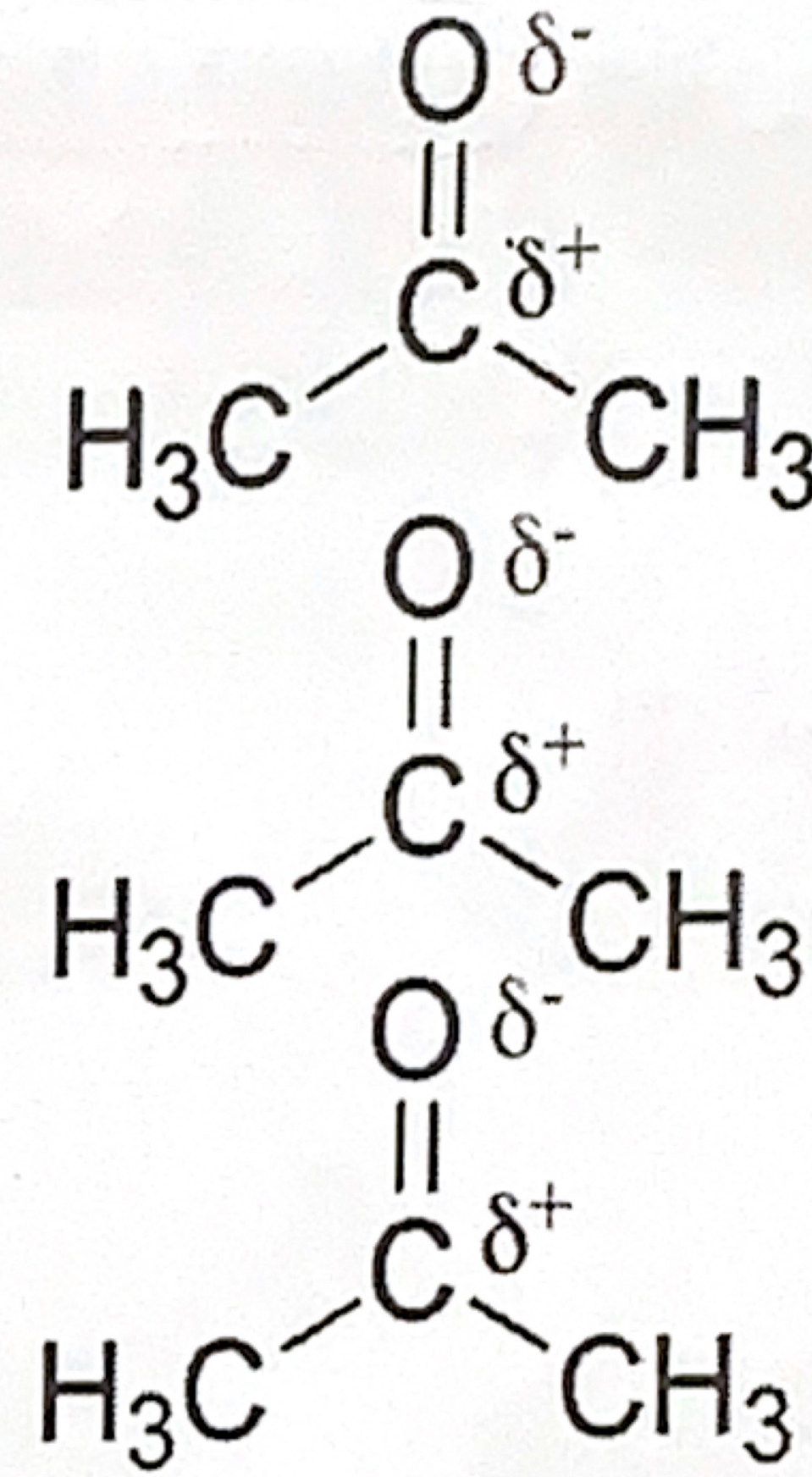
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Van der Waals forces

- Example of Keesom forces

- Acetone Polar solvent

الأكسجين يفضل تسحب e^- من الكربون
(Dipole - Dipole)



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Van der Waals forces

- The oxygen molecule is nonpolar. (No charge)
- 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.

highly
Polar ← الأكسجين الذي بال water

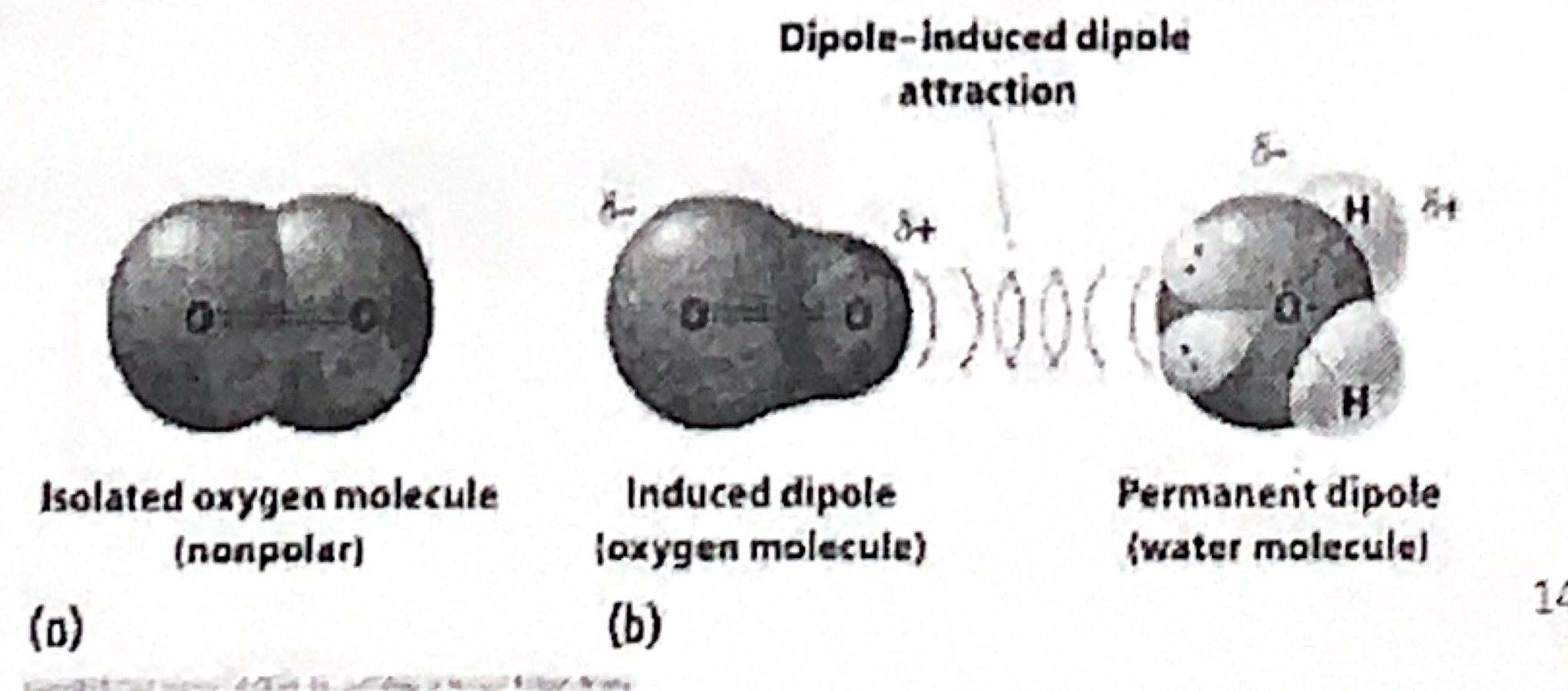
ومنا جزيء أكسجين آخر (non polar)

لما يقربوا على بعض ال O_2 تبعه الماء

عليها charge $\ominus$ ببعده Induction

للأكسجين الأخرى غلبت عليها

• $\oplus$ Charge



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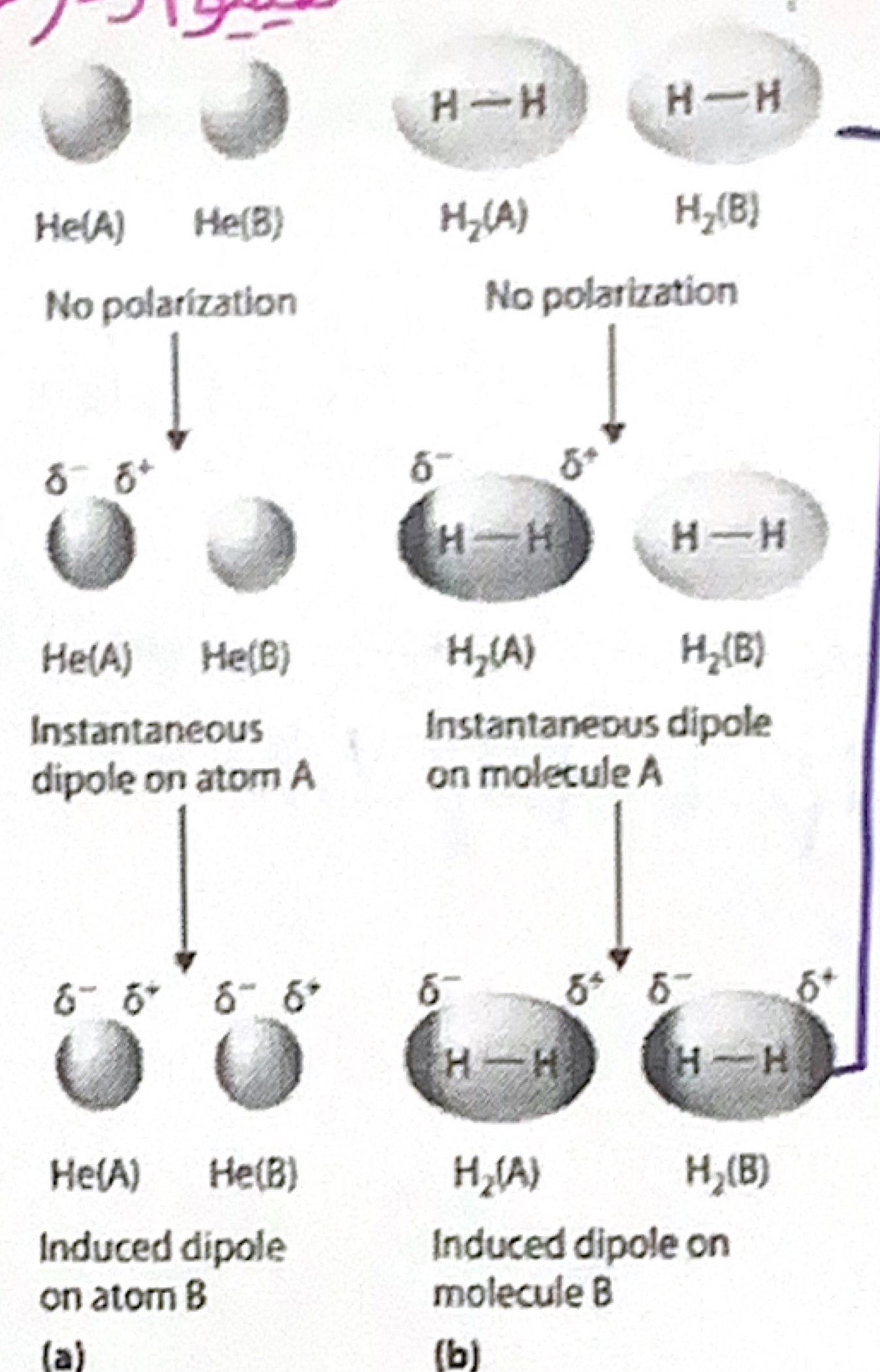
note: إذا distance جداً ممتدة
بال Induction ولو ما كانت
مناسبة ما يجسر (Induction)

Van der Waals forces

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

الإلكترونات تتوزع حول النواة
على شكل (Orbitals) مدارات

هيليوم (غاز خامل)



واحد بيسر
Dipole
بعد Induction
للي جيبه

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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).

كلما كانت الروابط قوية والـ σ ثابتة يكون تحريكها صعب
أما لو زادت الحركة بين الإلكترونات بيسر Induction أسهل

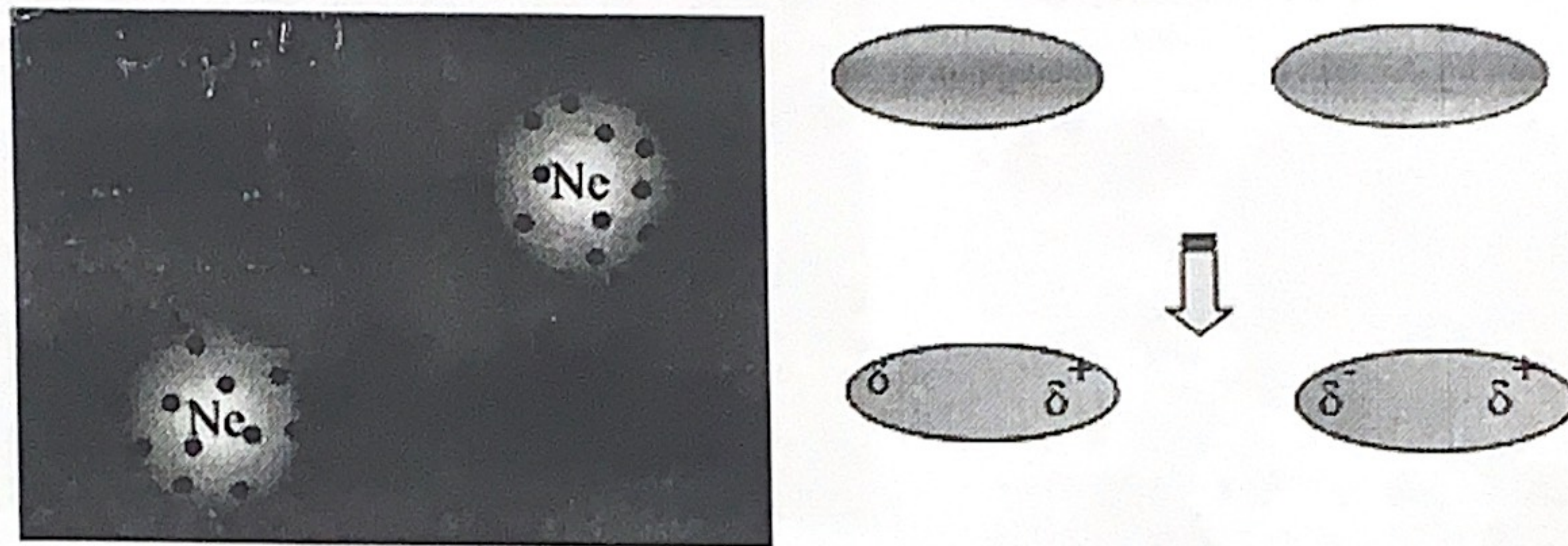
- Debye forces is weaker than Keesom forces because the dipole in the nonpolar molecule is temporary (induced) and forms only when the two molecules are extremely close to each other.

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الثنى (Non-Polar) تحت ظرف
معين واحد بهسره Induction
فبعد Induction للآخر

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)
- ← (الأضعف) weakest
- ← Nobel gas, (Neon), hydrocarbons (Benzene, hexane, etc)...
- خاملاً ما عليه شحنة



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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.

كلما زادنا عدد
المدارات بزيادة
عدد الـ e⁻ فبزيادة interaction

- This is because:
 - The electrons are farther from the positive nucleus and so are held less strongly
 - The number of electrons is greater
- London Force is the weakest of all the intermolecular forces.

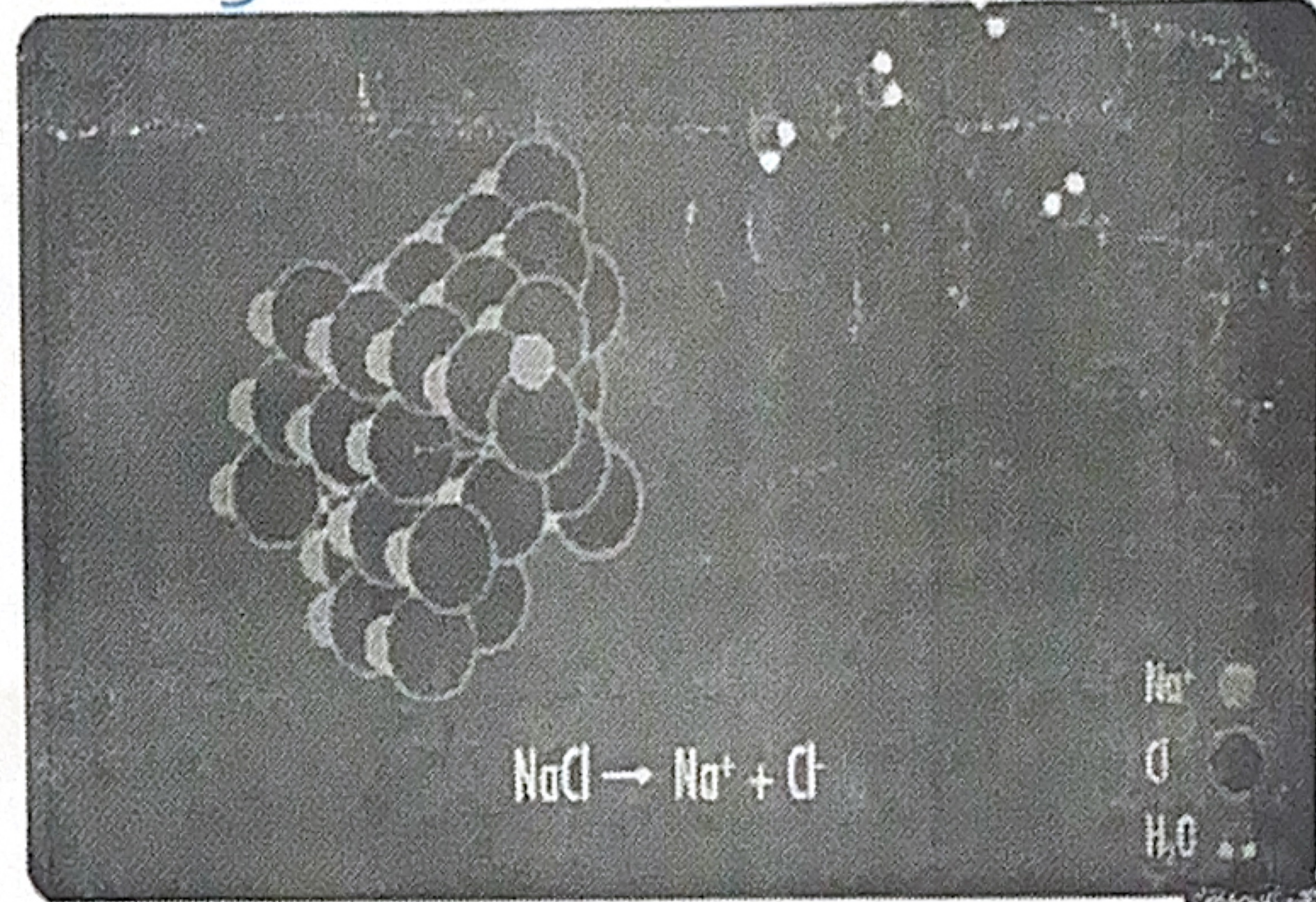
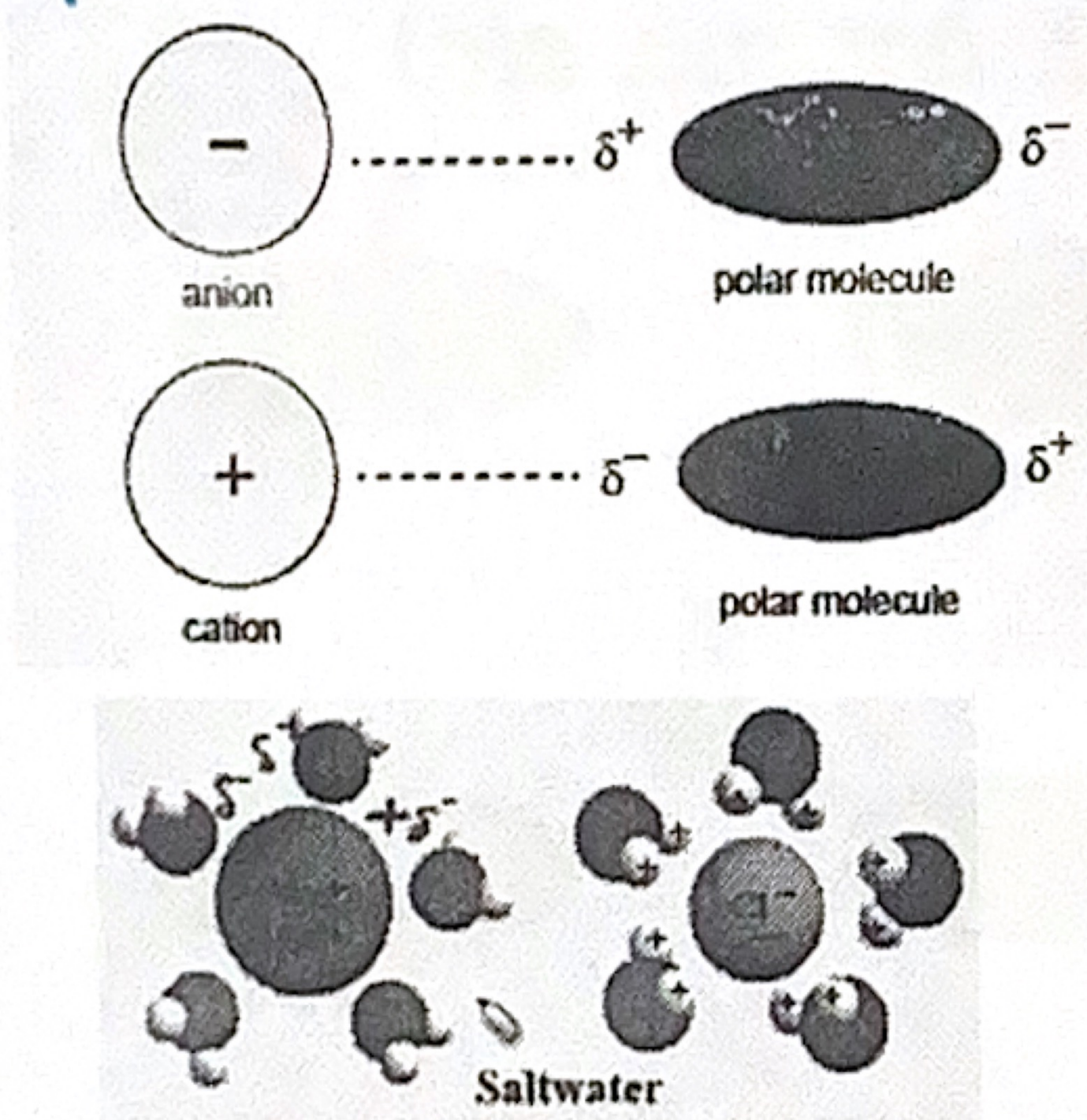
كل ما كبر العدد الذري
بهر في e⁻ أكثر عليها
فيكبر حجمها.
بس مثلاً الهيدروجين
عندها one e⁻
جداً قريبة من النواة
فصعب يعمل
Induction
وكل ما كبر بهسره
أسهل.

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NaCl - water

Ion-dipole forces

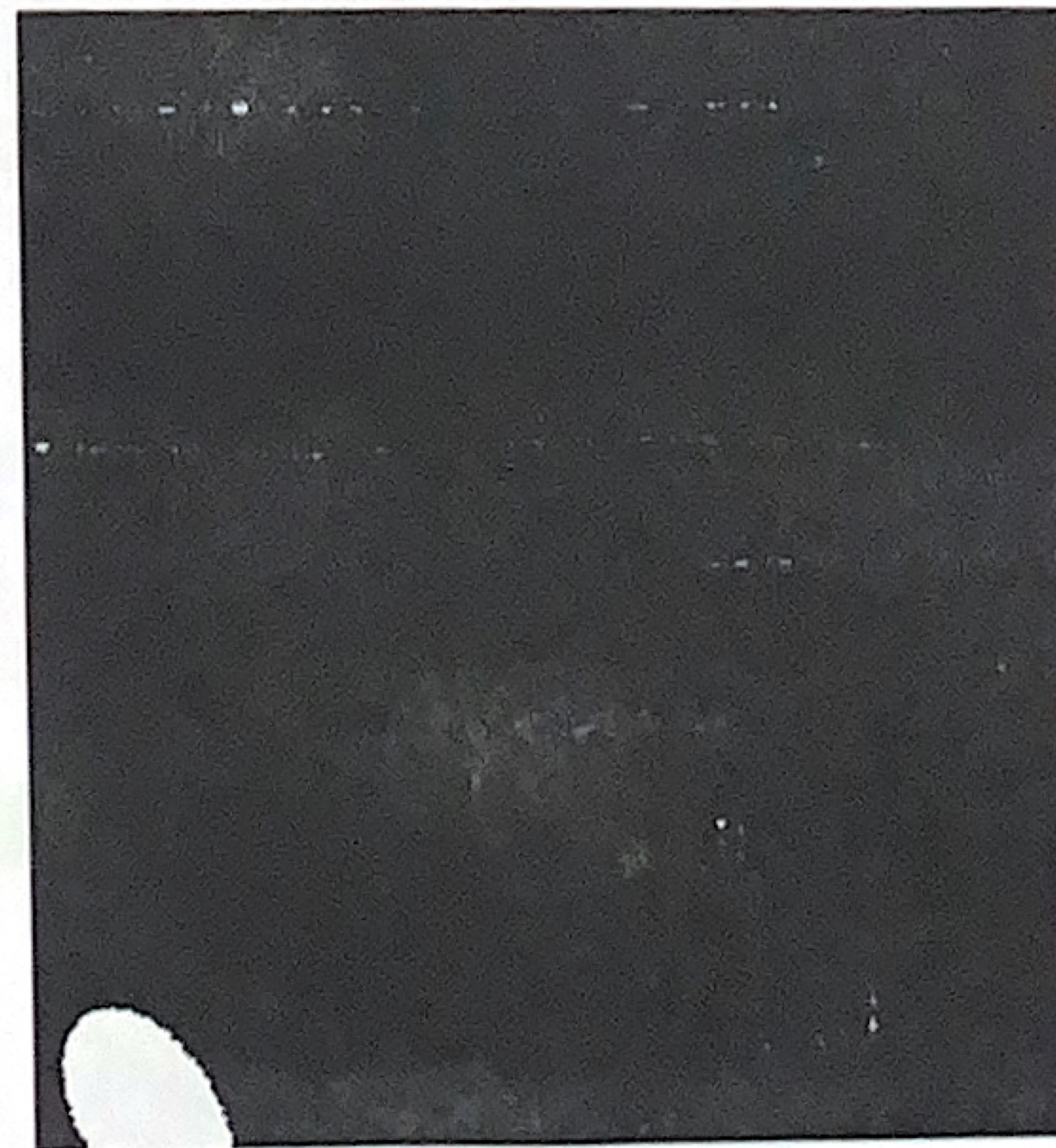
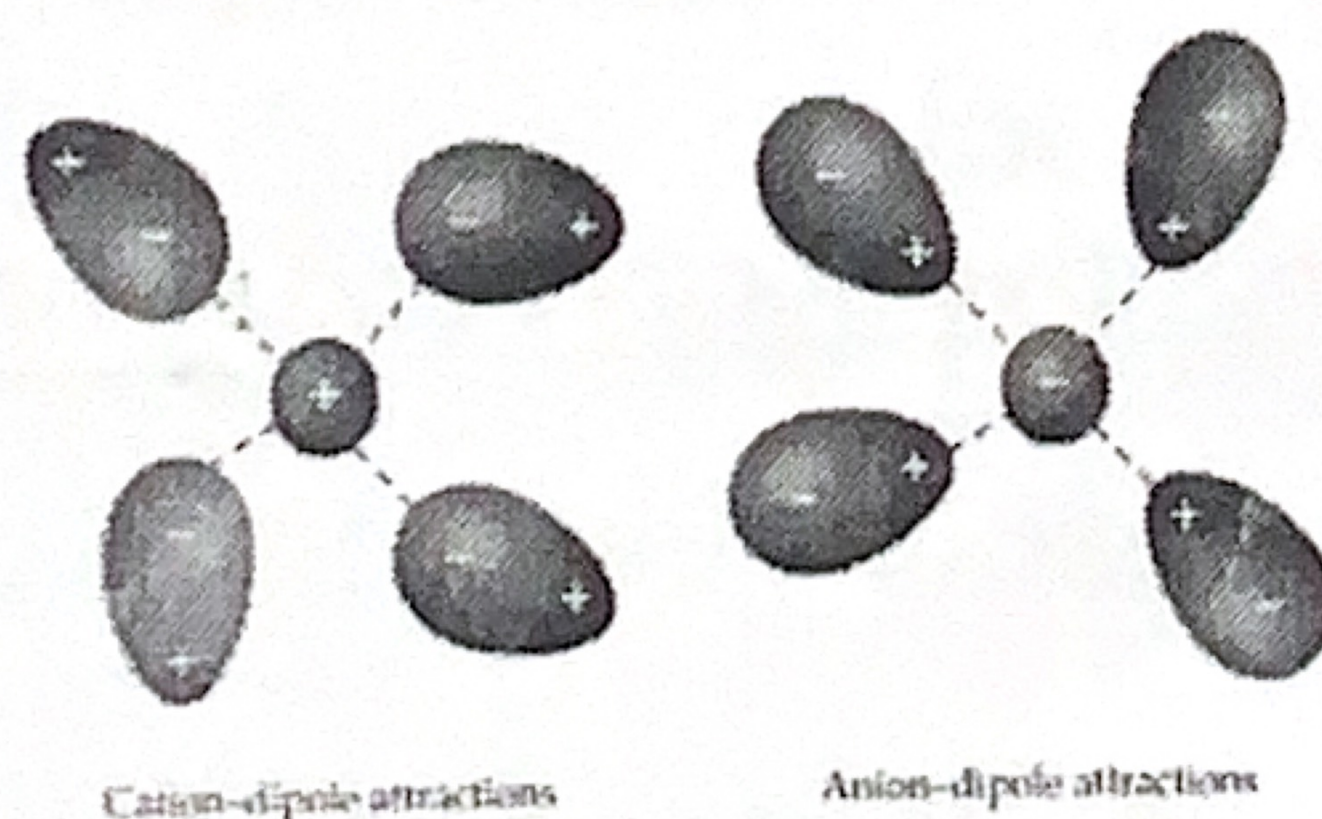
- These types of interactions account in part for the solubility of ionic crystalline substances in water; the cation, for example, attracts the relatively negative oxygen atom of water and the anion attracts the hydrogen atoms of the dipolar water molecules. → Positive
→ Negative



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Ion-dipole forces

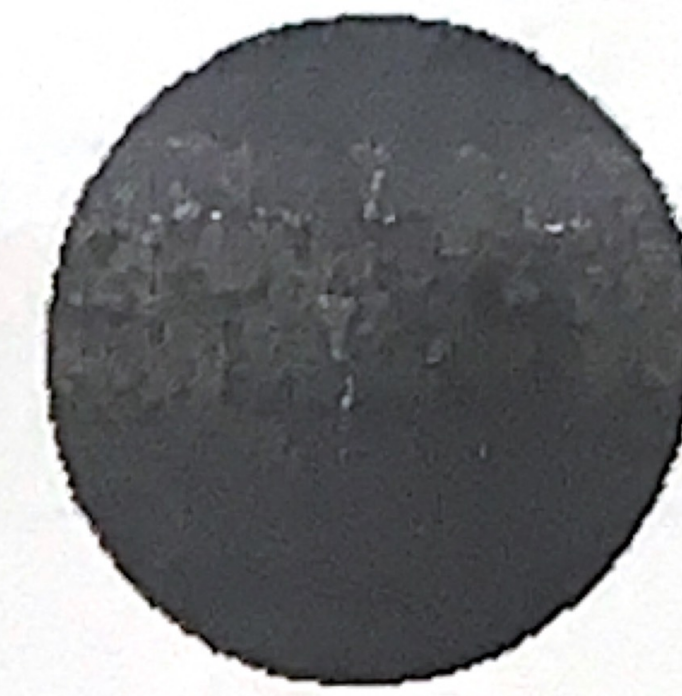
- Ion-dipole forces occur between a charged ion and a polar molecule (i.e. a molecule with a dipole) Cations are attracted to the negative end of a dipole, while anions are attracted to the positive end of a dipole



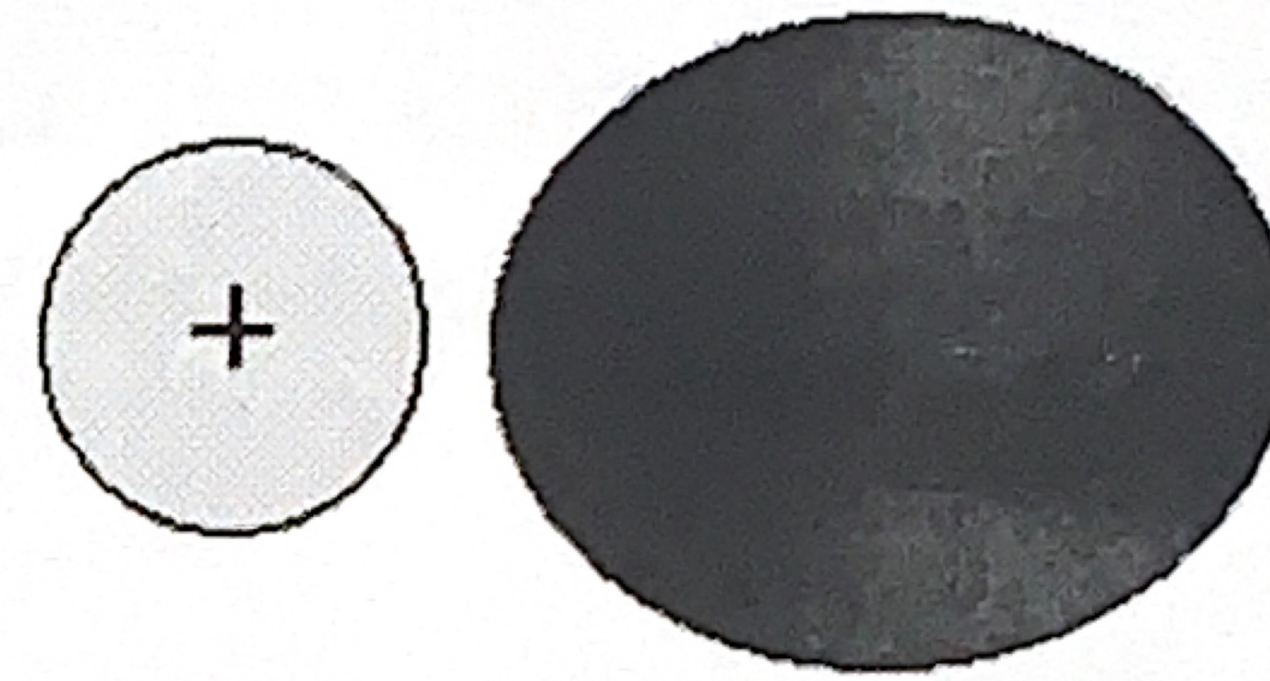
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Ion-Induced dipole

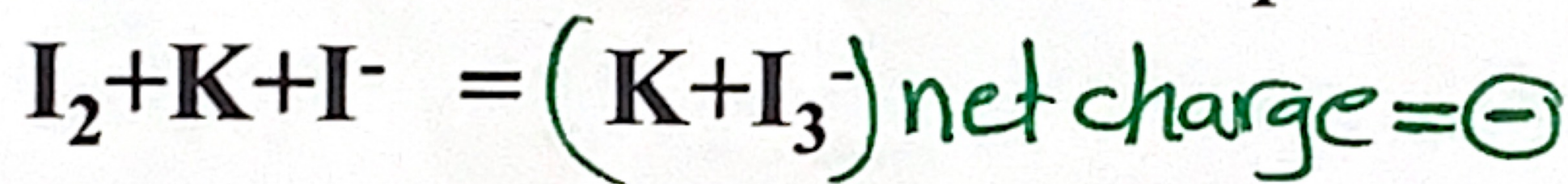
- (Ion-Induced dipole forces) occur between a charged ion and a nonpolar molecule.
- These forces result when the approach of an ion induces a dipole in an atom or in a nonpolar molecule by disturbing the arrangement of electrons
- Ion-induced dipole forces are presumably involved in the formation of the iodide complex



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



Non-Polar ← Iodine (I_2)

(Ion) ← Potassium Iodide (KI)

اليود مركب كيميائي

لا يذوب بالماء
(insoluble)

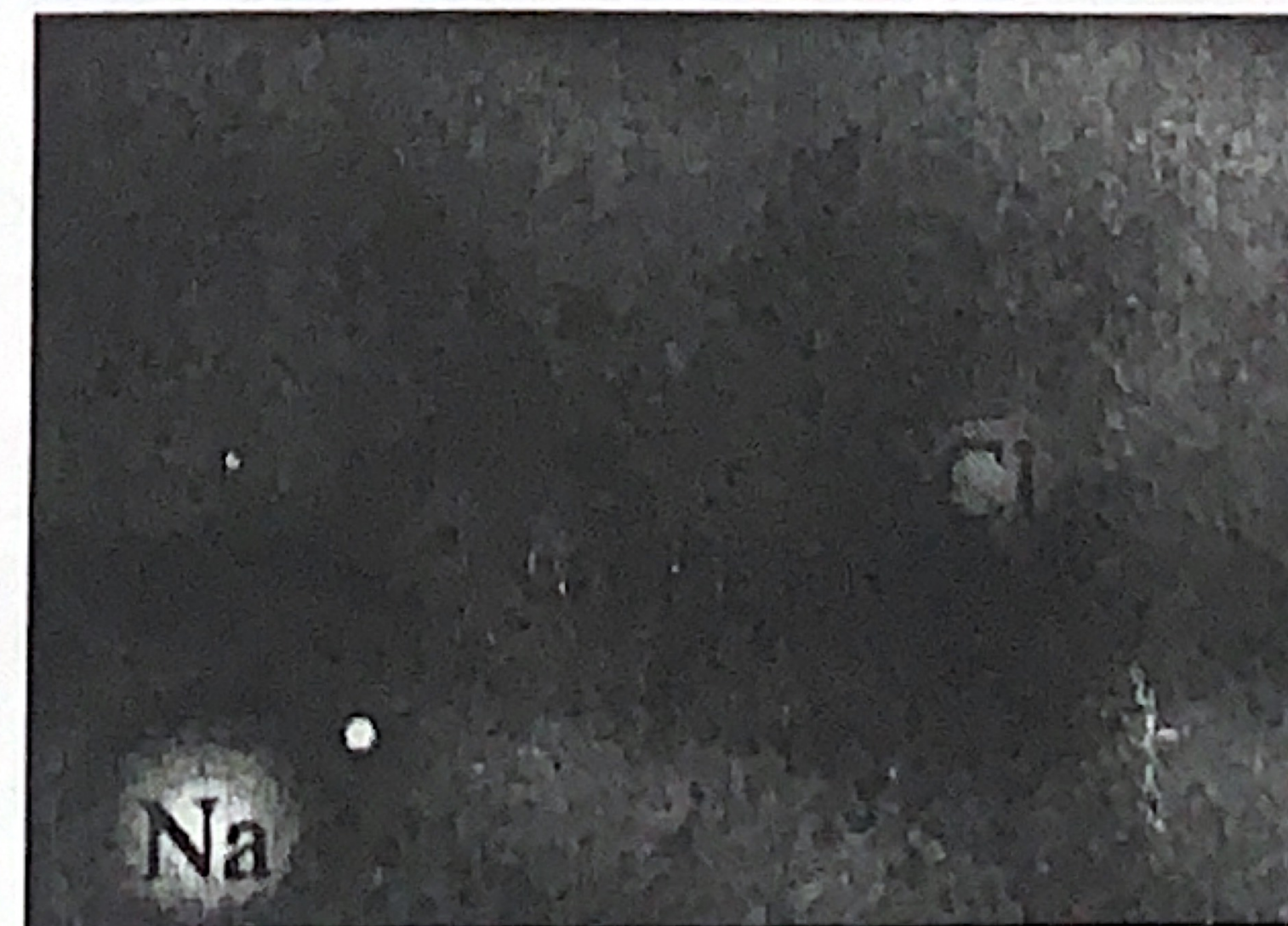
فإن خلطه مع (KI)

فإنه يذوب (soluble)
complex

بعضه (Lugol's solution)

Ion-ion interactions

- A cation on one compound will interact with an anion of another compound.
- 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).



مركب أحادي
weak acids or bases

dissociation
وعشان تذوب بالماء بنحوه

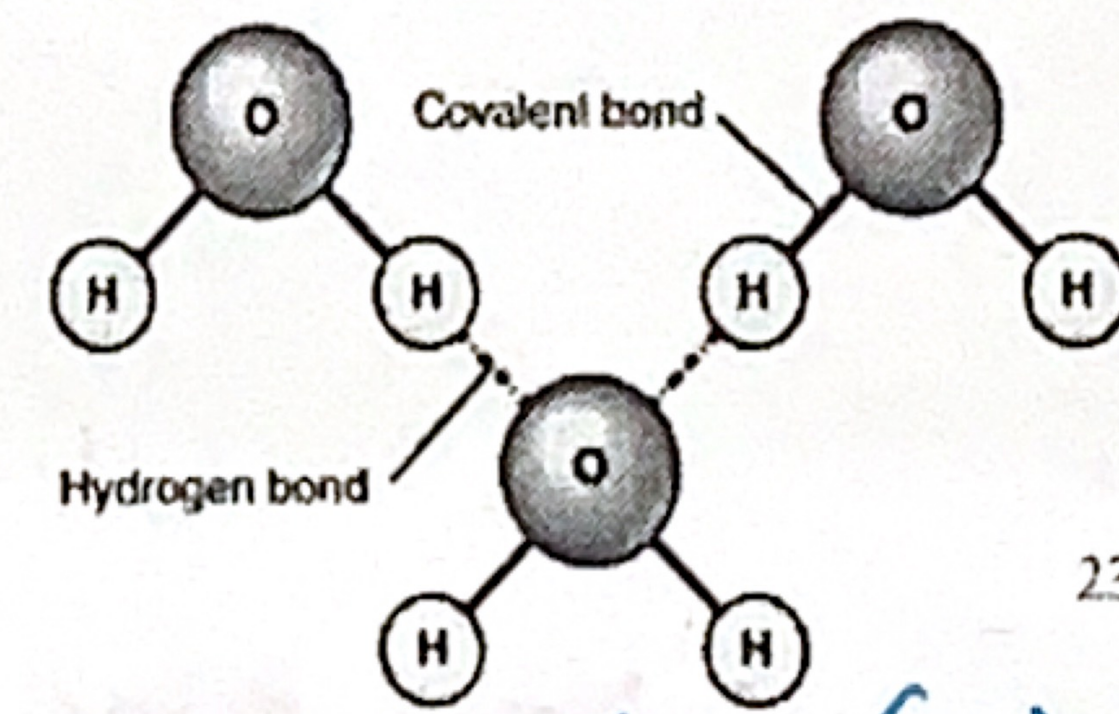
على (Salt) فبتزيد

ذائبة بالماء لأنه يفسر
charge

Hydrogen bond

(Partial)

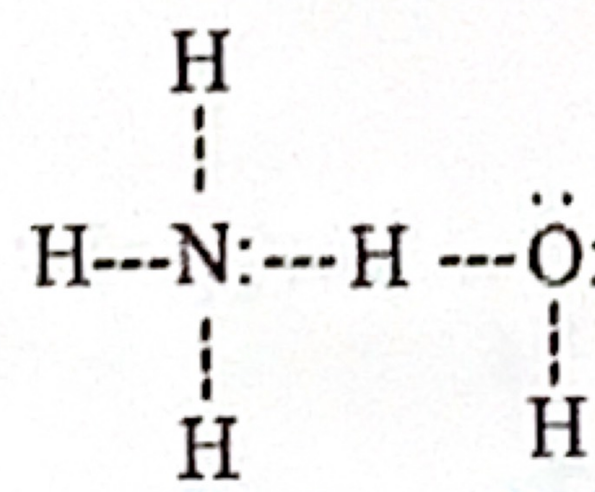
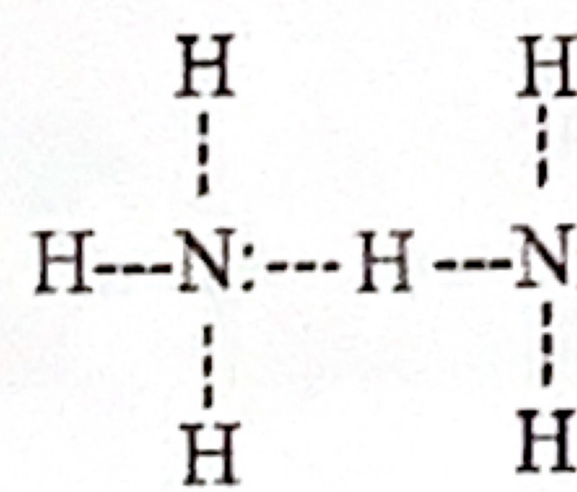
- Hydrogen bond is a strong type of (dipole-dipole) interaction that occurs between a molecule containing a (hydrogen atom) and a strongly electronegative atom such as fluorine, oxygen, or nitrogen
- In order to create the bond, the hydrogen atom must be covalently attached to another electronegative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



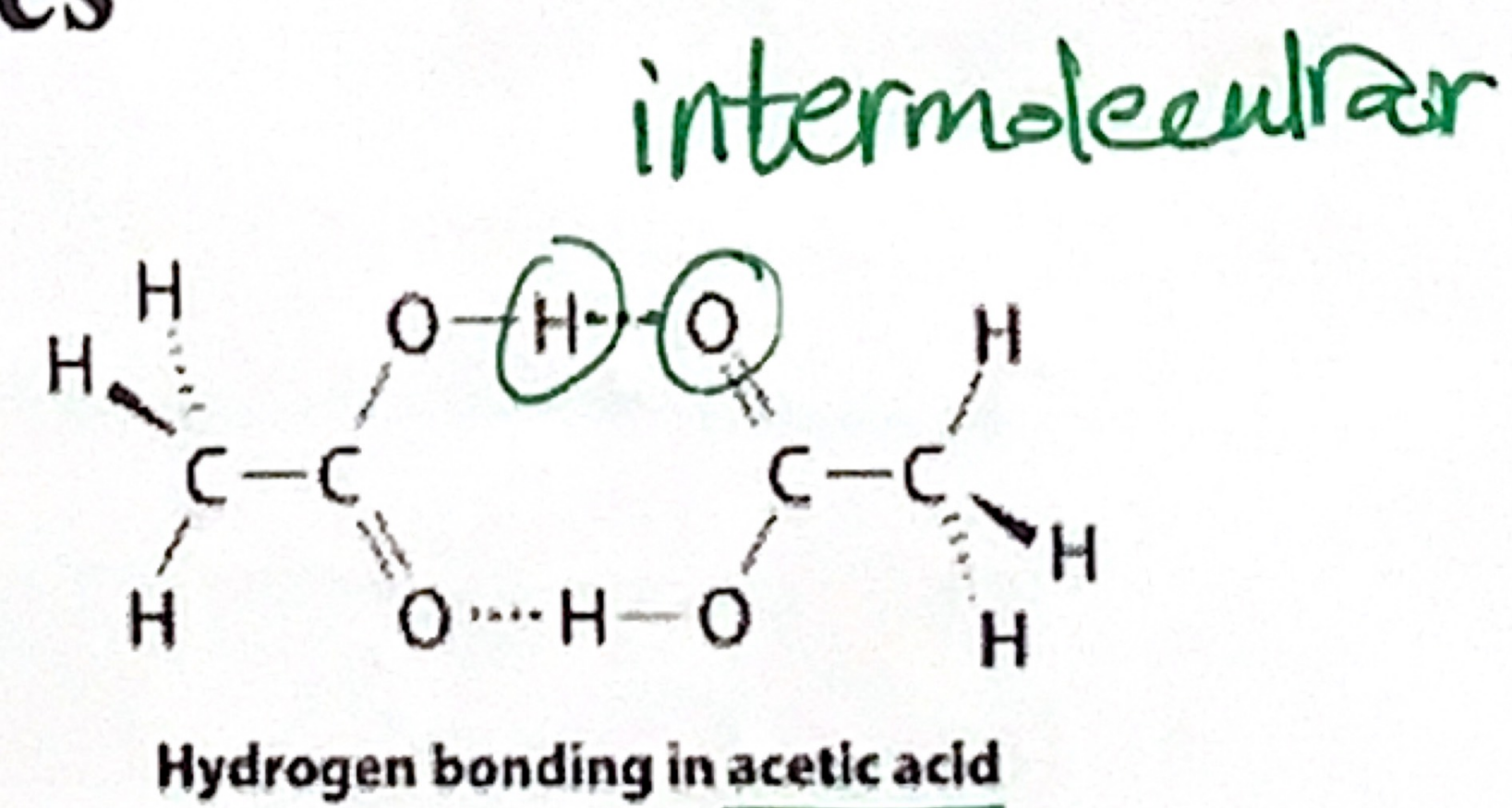
eg: water (intermolecular)

Hydrogen bond

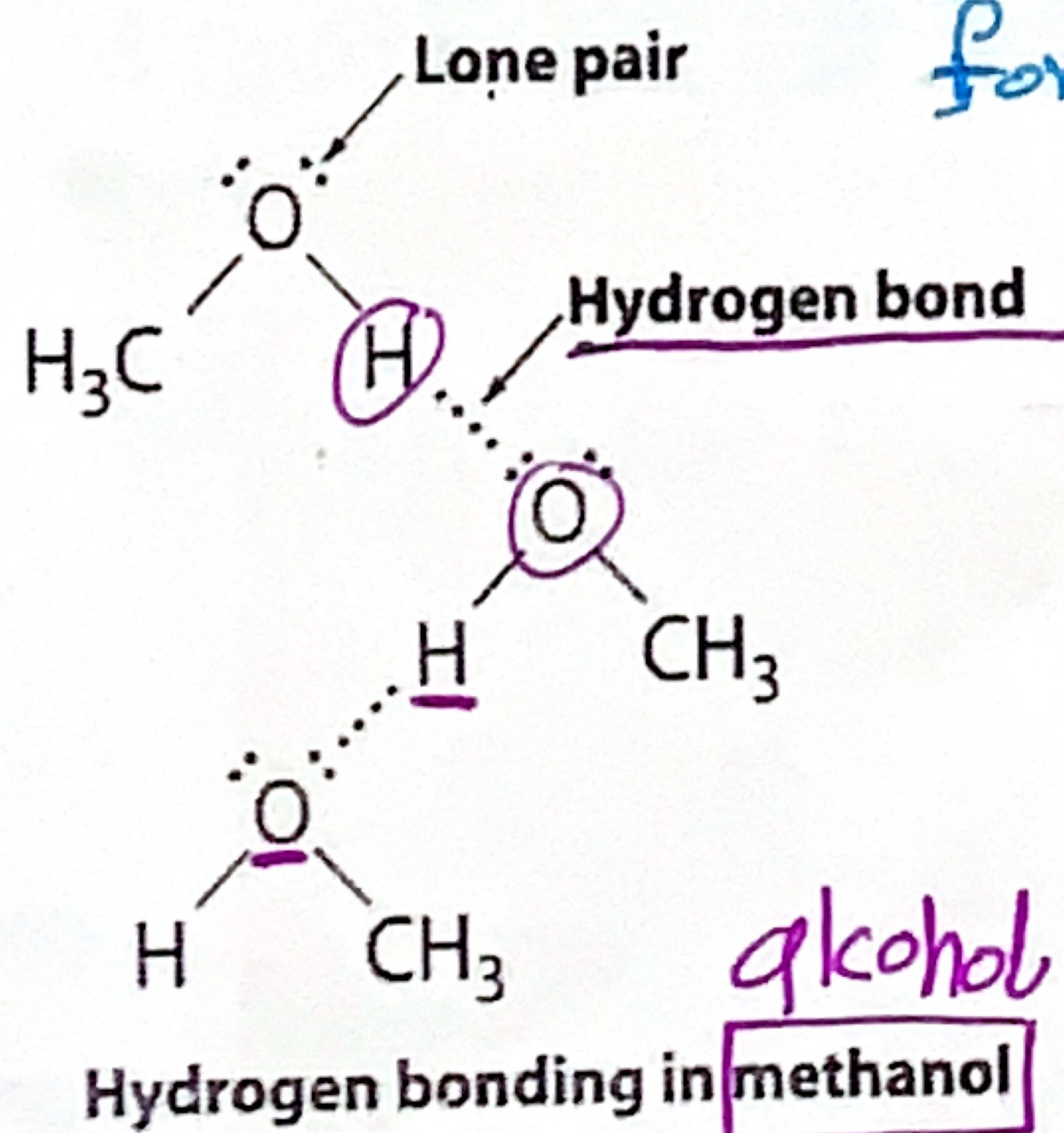
Examples



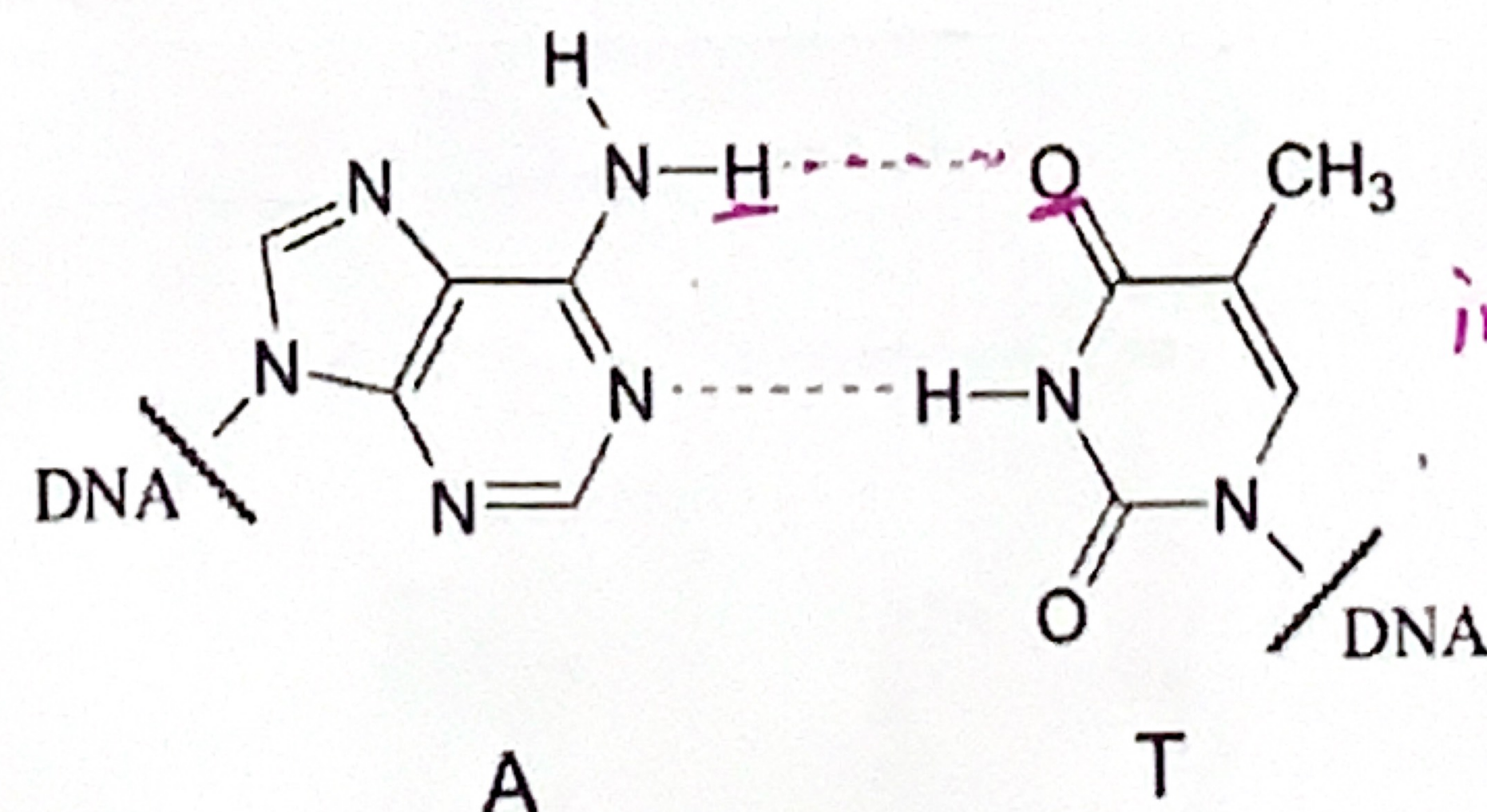
intermolecular force



Hydrogen bonding in acetic acid



Hydrogen bonding in methanol



(DNA Bases)

Hydrogen bond

سبب كل خصائص
الماء الغير عادية

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.) (ice has large volume than liquid)

لما يتجمد عليه ماء
بكبس حجمها ويقل
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. full ionic

Sharing

* سبب الـ Surface tension على سطح الماء (التقوس)

لأنه الماء الروابط فيه قوية جداً والـ (hydrophobic) air
فجزيئات الماء تتجذب نحو المركز فالروابط بين الماء نفسه
أقوى من الـ interaction بين الـ water + air

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Bond energies

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

الاشياء اللي يكون فيها
(Ion) يكون اقوى
دائماً

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Importance of intermolecular forces

بأنهم على طبيعة الماء
gas, solid, ...

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:

surfaces ② → يكونوا
وسيتفاعلون مع
interaction

Interfacial phenomena: are the ones that occur at the limit between two immiscible phases, so-called surface or interface.

لا يمكن أن يكون بينهم
repulsion

Flocculation of suspensions: is a process wherein colloids come out of suspension in the form of floc or flake. (not cake)

Stabilizations of emulsions, Emulsion stability refers to the ability of an emulsion to resist change in its properties over time.



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Reminder emulsion: Avoid Freezing

good
لا يمكن أن يكون بينهم
forces
لأنه وجود الهواء بأنهم عال

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.

البخاخ مثلًا لازم حجم
droplet يكون صحيح

لا يمكن أن يكون ثابتة وما
تتغير ولا يمكن أن يكون في
good adhesive
forces.

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.

ال details من
مطلوبه
فقط للعلم

من المهم

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