12.01.2022

2·5nm → 5·0nm

Nano Particles of Semi Conducting materials.

(Same material → diff size Particles)

Emitted Light → After they were exposed to UV Light.

→ Same material

(*) Emission property is a function of Size.

Same Concept

⇒ At the nano. Scale, Intensive Properties become Extensive.

one of the most unique feature of the Nano Scale.

Unique about Nano

(1) Properties become size dependent.

↓

Intensive properties

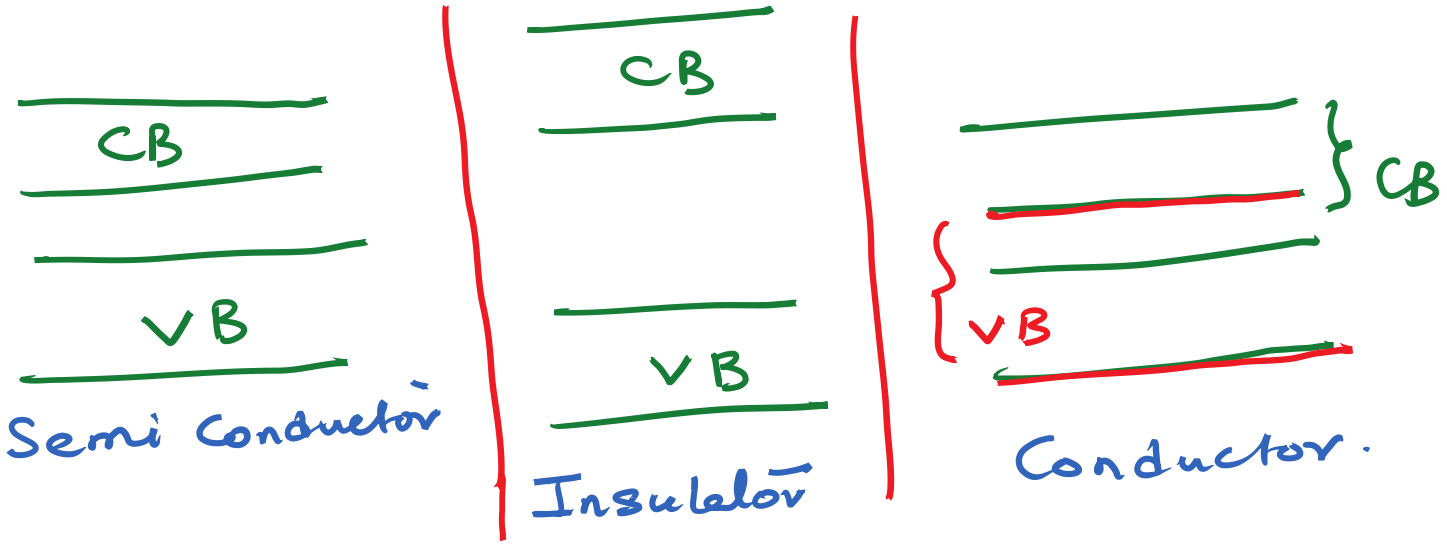
Band Structure of materials → What happens at the nano scale is as size becomes too small (~ few 10s of molecules)

→ The band structure starts to change.

→ All unique properties.

Valence Band (VB)

Conduction Band (CB)



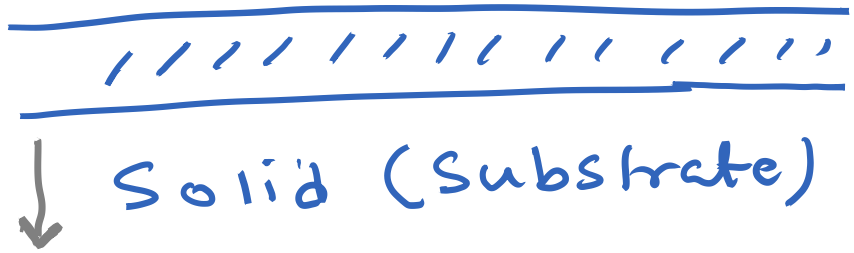
Thin Film

100 nm
10 nm
etc.

What is this?

12.01.2022

Class # 2



Solid (Substrate)

Thin Layer of material (Thin Film)

→ Paint on wall.

(Supported Thin Films)

→ Very Stable.

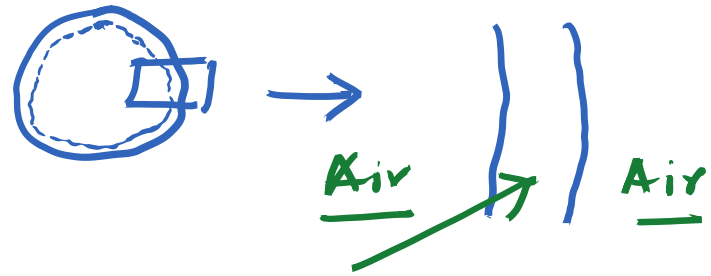
Ellipsometer
For thk measurement

Oil on Water

Supported Thin Film

Support → Is a Liquid or on a DEFORMABLE Support.

Soap Bubble



Soap Containing water film

Thin Film

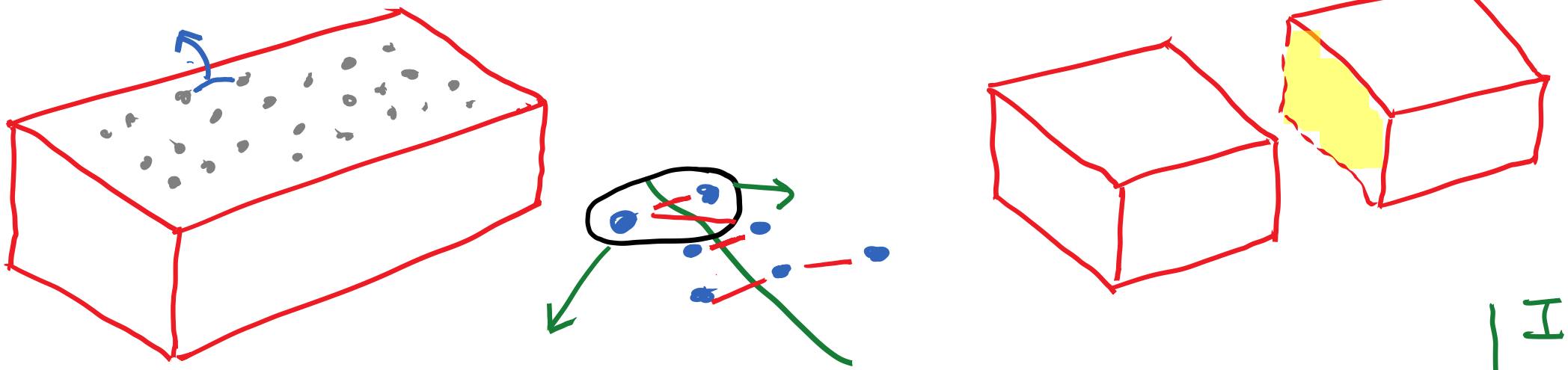
UN-SUPPORTED

Self Standing Film

ON HOLD!

Surface Tension:-

Energy required to create unit area (surface) of a material.



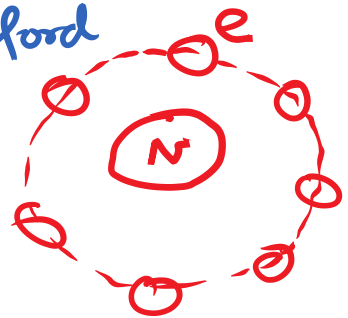
"Seperating" these molecules

What was binding the molecules? → vanderwaali Force

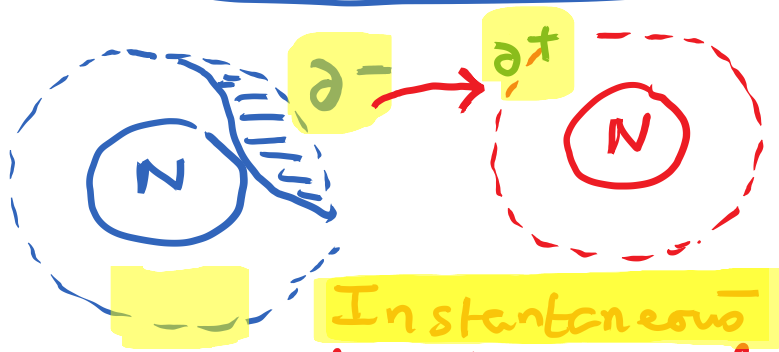
Induces a instantaneous Positive charge on the neighboring atom/molecule

= Attractive Interaction.

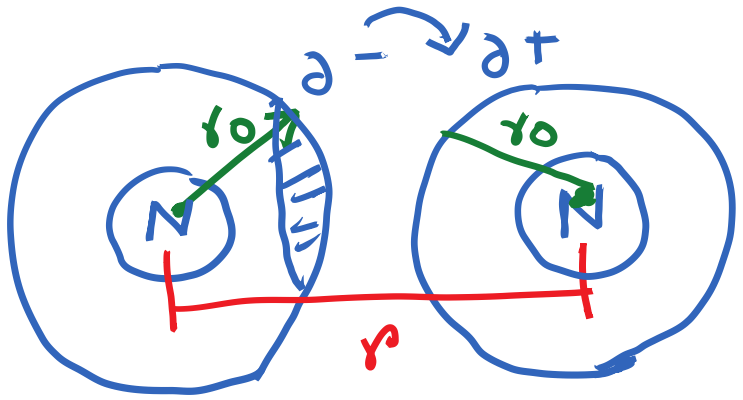
Rutherford Atom



In reality the electrons are undergoing high frequency rotation around Nucleus



Instantaneous Localisation of electronic charge.



This molecule has no permenent dipole

Intermoleculer Interaction

Nature of this interaction: →

Induced dipole – Induced dipole Interaction.

Always present In all meterials.

London Dispersion Force

Van der wael's Force

1. Induced dipole - Induced dipole.
2. Permenent dipole - Induced dipole.
3. Permenent dipole - Permenent dipole.
   - ↳ Hydrogen Bonds

Strength of VdW Interaction

$$\propto -\frac{A}{r^6}$$

r = Sepn distance between the atoms/molecule

A = constant

'–' sign → Attraction

What is the Lowest value of 'r' possible? → Not Zero

If r=0 → Lead to nuclear Fusion.

Van der Waal's Interaction → Induced dipole - Induced dipole

$$\sim -\frac{A}{V^6}$$

Van der Waal's (E.O.S)

$$\left(p + \frac{a}{V^2}\right)(V - b) = RT$$

$\frac{a}{V^2}$ → ID-ID interaction

$\frac{a}{V^2}$ → Increase in Pressure → Pressure Correction

If velocity increases, Pressure would Increase

$\frac{a}{V^2}$ ⟵ | ⟶ VdW

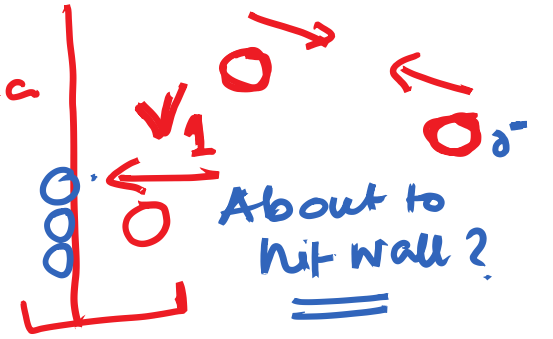
$-\frac{A}{V^6}$

$V \approx r^3$

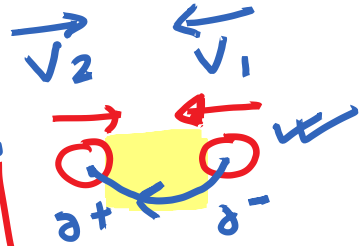
Hits the wall with a velocity $(V_1 + \delta V_1)$

↓

Pressure Increases.



ID-ID interaction takes place



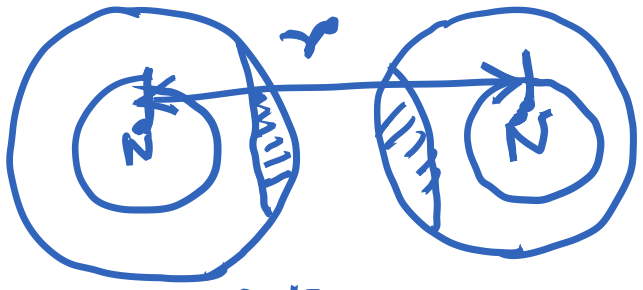
Just ahead of Collission of a gas molecule with the wall, ID-ID interaction starts. → So there is attraction !!

(Short Range)

$\phi_a \sim -\frac{A}{r^6}$

as $r \to$ increases

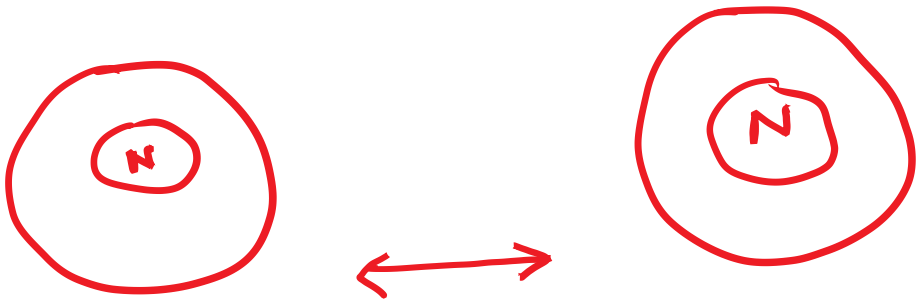
$\phi_a \to 0$



How far these van der Waal's Interactions act? → r_{max} for which $\phi_a \neq 0$

Arguably $r \approx 10nm$ or Lower

(Short Range)



Interaction will drop → 0

Strength of Gravitational Force (Potential Energy) → mgh

Intermolecular Interaction → Internal Potential Energy

Internal Energy → Internal KE.

[Energy Associated with Rotation & Vibration. = Intra molecular Interaction

Is vdW interaction related to any compont of Internal Energy.

What is the difference between a Liquid and a Gas in terms Internal Energy.

Gas $k_B T$

Internal Energy → Internal K.E

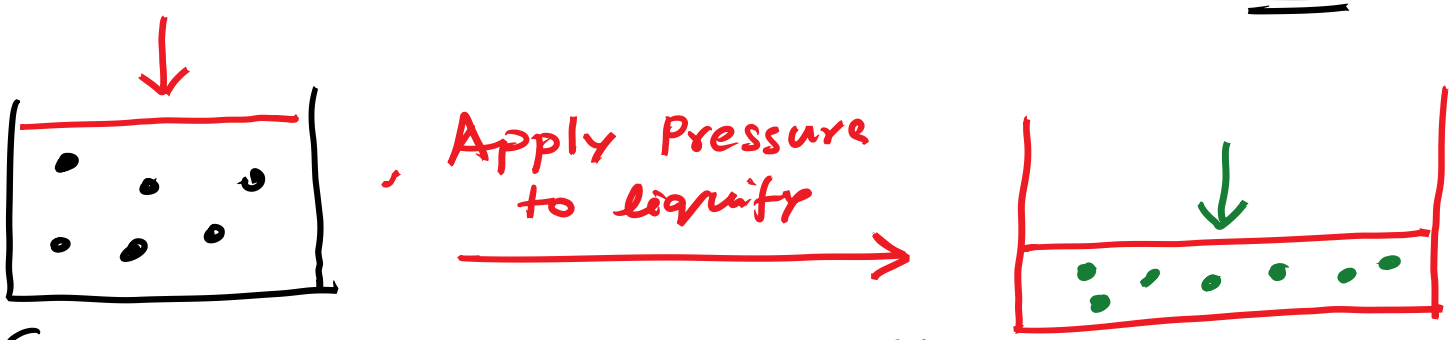
Liquid $-\frac{A}{r^6}$

Internal Energy → Internal P.E.

What is critical Temperature:- T_{cr}

↳ Liquification is not possible.

(*) For $T \geq T_c$, the strength of KE becomes so high that PE can never exceed it.



If T is increased, KE keeps on increasing
PE ≠ f(T) → Does not Increase.

Intermolecular distence reduces

If the strength of PE (Intermolecular Interaction) Exceeds to KE (The tendency of molecule to move away)

→ Liquifaction Takes place.

13.01.2022

Lecture - 03

Surface Tension →

→ Thin Film → Supported Film vs. Self Standing Film.

→ van der Waal's Interaction → Inter molecular interactions.

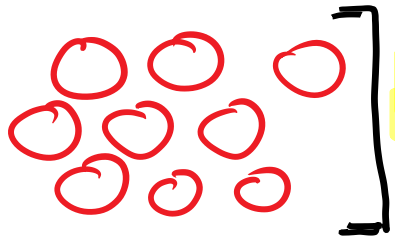
→ Induced dipole - Induced dipole.

Generic to any material.

→ In case polar material.
(There is permanent dipole)

→ Permanent dipole - Induced dipole etc.

Intermolecular interaction is responsible for:



Cohesion

In the Condensed Phase.

→ Cohesive Interaction: Intermolecular Interaction between Molecule of same material.

Condensed Phase are those → Intermolecular Interaction is non zero.

CONDENSED PHASE (Liquid, Solid)

Non Zero Intermolecular Interaction

Non Zero Internal Potential Energy

(Mean Free path → 0)

NON condensed (Gas)

≃ 0.

(Mean Free path of the molecule → ∞)

Van der Waal's Eqn of State → $\left(P + \frac{a}{V^2}\right)$ → Related to Intermolecular vdW Interaction

Intermol. Interac $\propto -\frac{A}{r^6}$, Int. KE k_BT

Critical Temp.

↳ Increase the temp → Strength of Internal PE does not Change.

→ Internal KE shoots up.

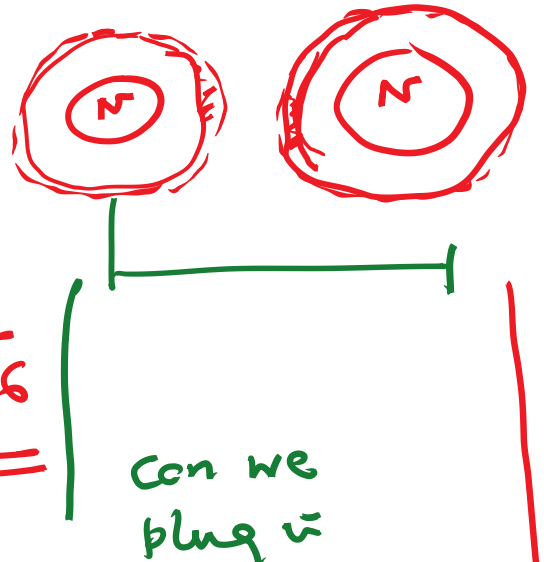
What happens when two atoms/molecules come towards eachother :-

Strong Electrostatic Repulsion

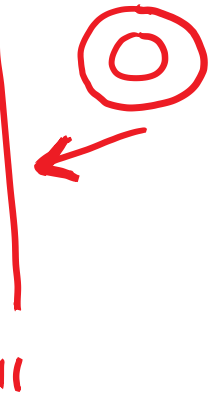
Potential Curve

As the molecules/atoms approach eachother, their outer electronic orbitals would come in contact.

$F = \frac{A}{r^6}$



Can we plug in $r = 0$?



Wall

Internol- Interechi- Forcee (F)

$r \approx 10\,nm$

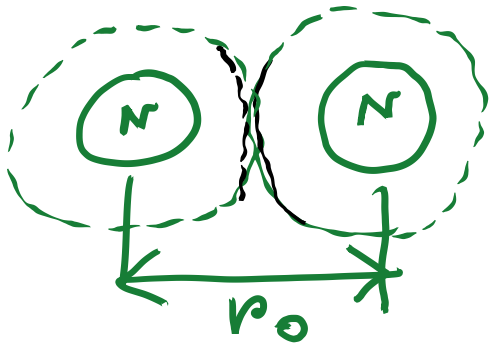
$\Rightarrow$ Min possible value of $r = r_0$.

Repulsive Interation

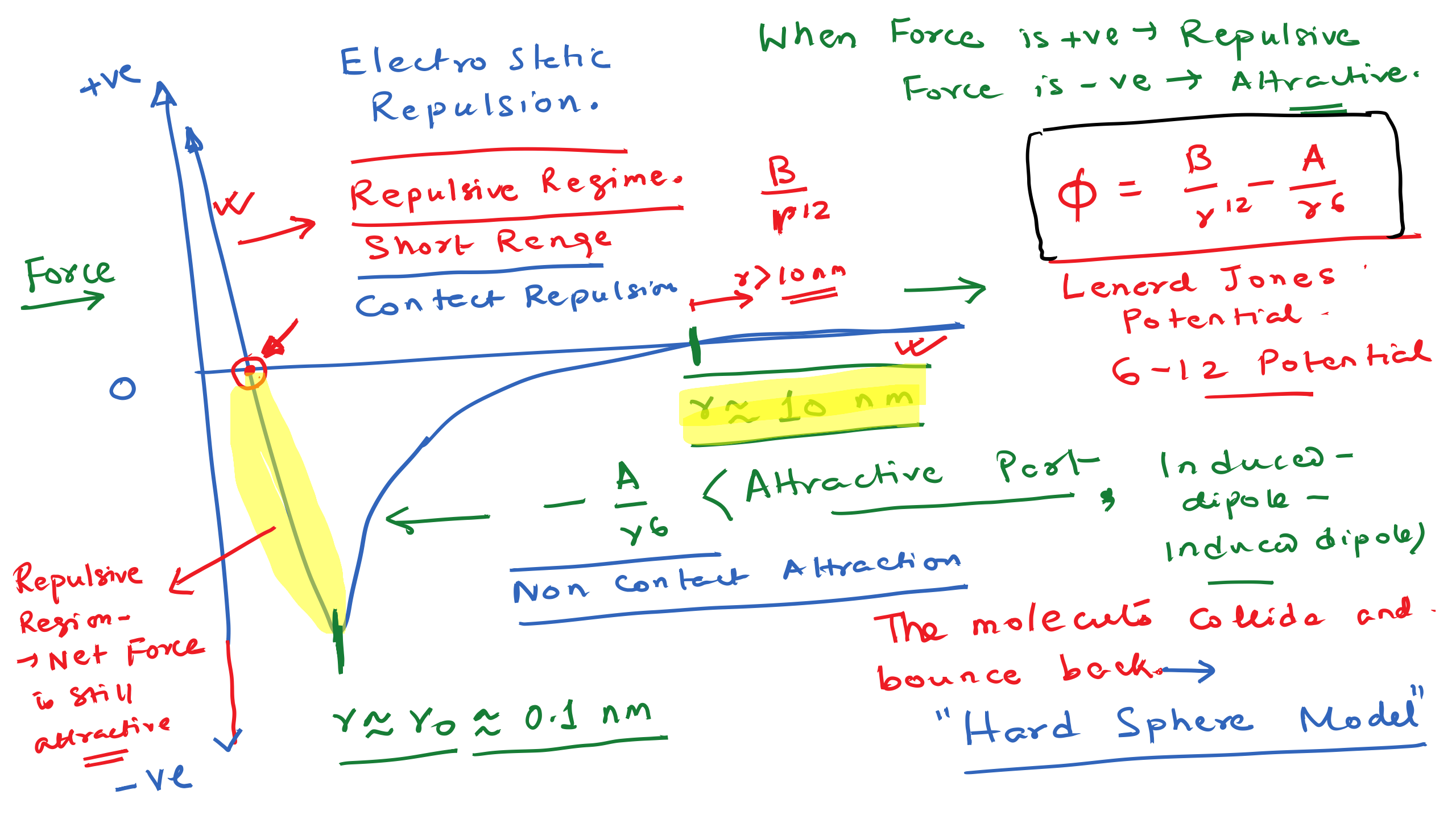
Born Repulsion

Mathematically

Only active for $r_0 < 0$



The attraction is due to I.D - I.D interaction between electronic clouds.


+ve
Force
0
- ve
W
Repulsive Region-
→ Net Force is still attractive
Electro Static Repulsion.
Repulsive Regime.
Short Renge
Contact Repulsion
B/r12
r > 10 nm
W
r ≈ 10 nm
- A/r6
Attractive Part
Non contact Attraction
r ≈ r0 ≈ 0.1 nm
When Force is +ve → Repulsive
Force is - ve → Attractive.
Φ = B/r12 - A/r6
Lenerd Jones Potential
6-12 Potential
Induced-dipole - Induced dipole)
The molecule collide and bounce back →
"Hard Sphere Model"