

UNIT \Rightarrow 3SURFACE & INTERFACIAL PHENOMENON \rightarrow Interface

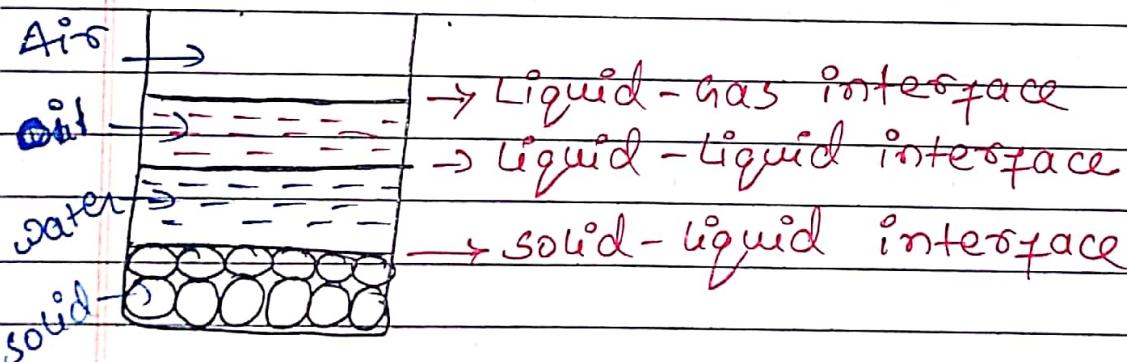
- It forms when two or more immiscible substance contact with each other.

or

A boundary between two phase which exist together is known as Interface.

Liquid Interface :

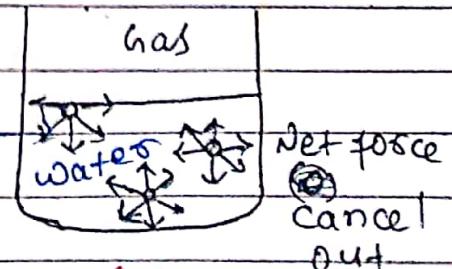
- It form when liquid is contact or mix with other states of matter then form liquid Interface.



Surface & Interfacial tension

 \rightarrow Surface tension :

- Surface tension is defined as tensile force acting \downarrow at the surface of liquid which is in contact with gas.
- Its unit N/m



→ Interfacial tension

- It is the force per unit length existing at the interface between two immiscible liquid phases.
- If two liquids are completely miscible, no interfacial tension exist between them.

Surface free energy

- The molecules near the surface of liquid have more potential energy as compare to the molecules in the bulk of the liquid (due to surface tension).
- This means that as surface of the liquid increases, the more molecules have potential energy.
- Surface of the liquid ↑, energy of the liquid ↑
- Energy is proportional to the size of the free surface called Surface free energy.

$$w = \gamma \cdot \Delta A \rightarrow \text{inc. in Area}$$

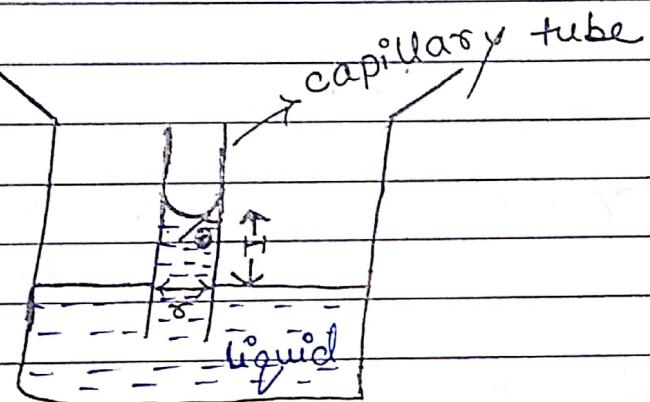
work done
or
surface tension
surface free energy

Measurement of surface & interfacial tension

- i) capillary rise method.
- ii) Drop weight method.
- iii) Drop count method.
- iv) Wilhelmy plate method.
- v) Ring detachment method.

1) Capillary rise method :

- It is used to measure surface tension.



-> Principle :

- When a thin glass tube (capillary) is placed in the liquid, liquid rises up in the capillary tube upto certain height (h).
- It is because adhesive force b/w capillary and liquid is more than the cohesive force between intermolecular molecules of liquid due to surface tension.
- Some gravitational force is also apply on liquid which pull downward liquid.

• when both forces are equal liquid is in equilibrium and stable in that situation.

→ Derivation :

$$* \text{ Upward force} - \rightarrow \text{for water} [F = 2\pi r \cdot \gamma]$$

$$F = 2\pi r \cdot \gamma \cos\theta \quad \text{--- (i)}$$

where,

$2\pi r$ = circumference of that capillary.

$\gamma \cos\theta$ = surface tension & angle of contact

* Downward force

$$f = mgh + \omega \quad \text{--- (ii)}$$

where,

mgh = Potential energy w.r.t gravitational force.

ω = weight of liquid.

we know that, $\rho = \frac{m}{v} = \frac{M}{\pi r^2 h}$ [$v = \pi r^2 h$]

$\downarrow \text{mass}$
 $\downarrow \text{density of liquid}$
 $\downarrow \text{volume.}$

$$M = \rho \cdot \pi r^2 h \quad \text{--- (iii)}$$

Put eqn (iii) value in eqn (ii)

$$f = \rho \pi r^2 g h + \omega^2$$

- Now, liquid is in equilibrium means both force are equal.

- upward force = downward force

$$2\pi r \gamma \cos\theta = \rho \pi r^2 g h + \omega \quad [\text{for water } \theta = 1]$$

$$\text{for water} \Rightarrow \gamma = \frac{1}{2} [\rho g h r + \omega]$$

where γ = surface tension

ρ = density

g = gravitation

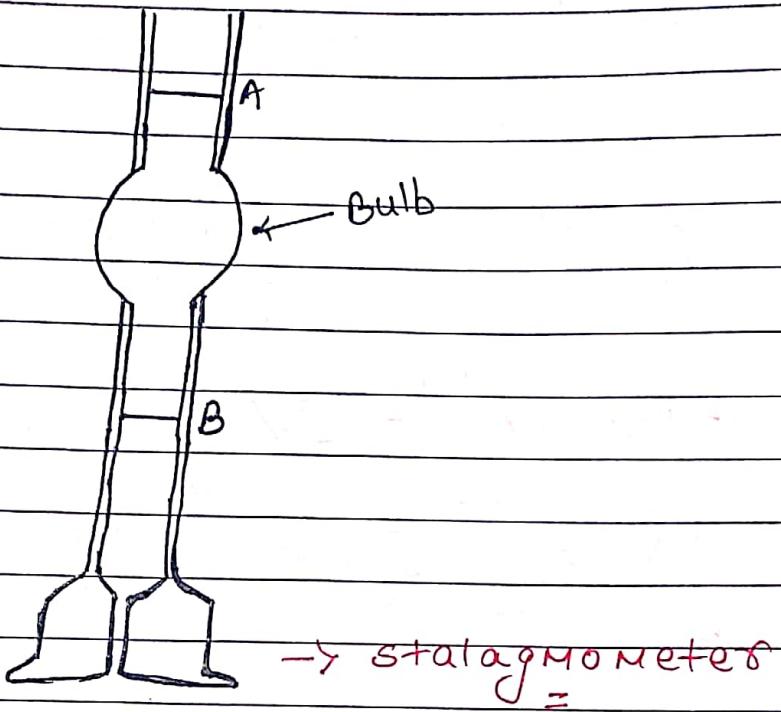
h = height of rising liquid

r = radius of that liquid

ω = weight of that liquid.

ii) Drop count method :

- It is used to measure the surface tension of liquid.



- first we take known liquid, which we know the surface tension.
- Then fill stalagmometer with that liquid at point A. Then closed from bottom with the help of fingers.
- Now, release liquid slowly - slowly dropwise from capillary until liquid reaches at point B, and continuously count no. of drop, then note it.
- Now do same with other liquid, which we have to find surface tension.

- So, on comparing both, by using formula to calculate surface tension

$$\gamma = \frac{w}{2\pi r}$$

$$\boxed{\gamma = \frac{mg \cdot n}{2\pi r}}$$

w = mass of drop

n = no' of drop

g = gravitational force.

3) Drop weight method :

- It is same as drop count method, in which we same use stalagmometer.

- Difference is that, we weight the drop (one drop), firstly those liquid which we know surface tension, then weight the other liquid drop which we have to find out the surface tension. of liquid is calculate by putting value in following equation :

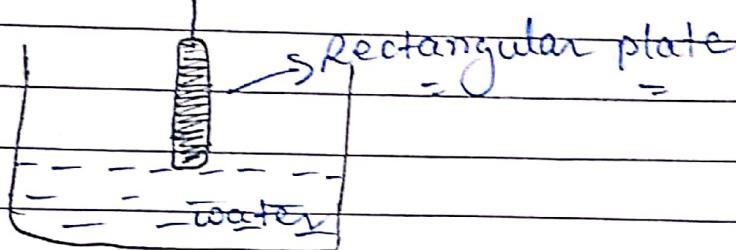
$$\boxed{\gamma = \frac{w}{2\pi r}}$$

4) wilhelmy plate method :

- In this method, the liquid whose surface tension is measured is put into container.

- A rectangular plate which is made up of glass or platinum is suspended vertically on the liquid.
- The plate is attached to torsion balance.
- The container is then gradually lowered so that plate detaches from the surface of liquid. The reading of the balance is recorded.

→ Torsion balance.



$$\gamma = \frac{\omega_L - \omega}{2(L+T)}$$

where, ω = weight of plate in air

γ = surface tension

ω_L = reading on the balance prior to detachment

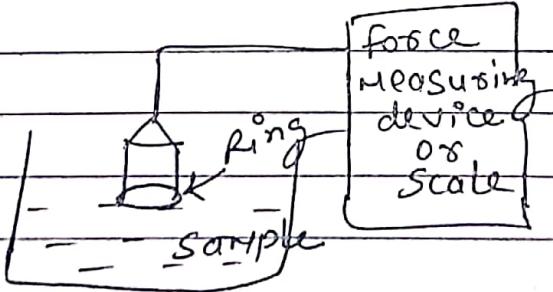
(when contact with liquid)

L = length of plate

T = thickness of plate.

5) Ring Detachment Method :

- It measure surface tension & interfacial tension of liquid.
- The liquid whose surface tension is measured is put into a container. A platinum ring is suspended ~~on~~ on the liquid.
- The ring is attached to a scale through torsion wire.
- The ring should just touch the surface of liquid.
- The force required to attach the ring is noted from scale.



$$\gamma = \frac{P}{2\pi(\tau_1 + \tau_2)}$$

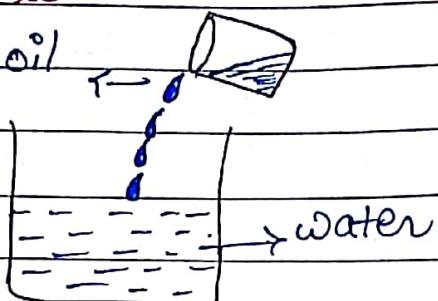
P = pull exerted through torsion wire on the ring.

τ_1 & τ_2 are inner & outer radii of disc.

II Spreading Coefficient :

- It is measure of ability of a liquid to spread over another liquid. is calculated as Spreading Coefficient.

oil



oleic acid/

olive oil
&
water

Film formation
(spreading)

^{non-polar}
^a
liquid
paraffin
&
water

Lens formation
(no spreading)

- In two immiscible liquid, when we placed 1st liquid drop on the surface of other liquid :
 - it will spread as a film . called spreading [calculate by Spreading Coefficient]
 - it will not spread becoz it form lens formation [we prevent our pharmaceutical cosmetic products by this lens formation]

- Adhesive forces :
- = =

- It applied on the different nature's of liquid. (eg \Rightarrow oil & water)

- Cohesive force :
- = =

- It applied on the same nature's of liquid (eg \Rightarrow oil & oil, water & water).

\rightarrow Note : The film formation is possible becoz adhesive force is more than cohesive force.

\rightarrow

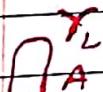
$$S = \omega_A - \omega_C \quad \text{--- (i)}$$

where, S = spreading coefficient

ω_A = work done of adhesive force.

ω_C = work done of cohesive force.

\rightarrow Derivation of 1st case (for cohesive force)



$$\omega_C = \gamma_L \cdot \Delta A + \gamma_L \cdot \Delta A$$



$$\omega_C = 2\gamma_L \cdot \Delta A$$

$$S \cdot T(\gamma_L) = \frac{F}{A}$$

$$\gamma = \frac{\omega}{A}$$

$$\omega = \gamma \cdot A$$

$$JF \quad \Delta A = 1 \text{ cm}^2$$

$$\omega_C = 2\gamma_L$$

--- (ii)

γ_L = surface tension of water

ΔA = Area of drop.

→ 2nd case (for Adhesive force)

$$\square \omega_A = \gamma_L \cdot \Delta A + \gamma_S \cdot \Delta A - \gamma_{L \cdot S} \cdot \Delta A$$

$$\square \gamma_S \cdot \Delta A \quad \text{IF } \Delta A = 1 \text{ cm}^2$$

$$\boxed{\omega_A = \gamma_L + \gamma_S - \gamma_{L \cdot S}} \quad \text{--- (iii)}$$

→ Put the value of ω_A & ω_C in eqn(i).

$$S = \gamma_L + \gamma_S - \gamma_{L \cdot S} - 2\gamma_L$$

$$S = \gamma_S - (\gamma_L + \gamma_{L \cdot S})$$

→ If $\gamma_S > \gamma_L + \gamma_{L \cdot S}$, then Spreading occurs

→ If $\gamma_S < \gamma_L + \gamma_{L \cdot S}$, then no spreading occurs.

Adsorption of liquid surfaces

positive adsorptn

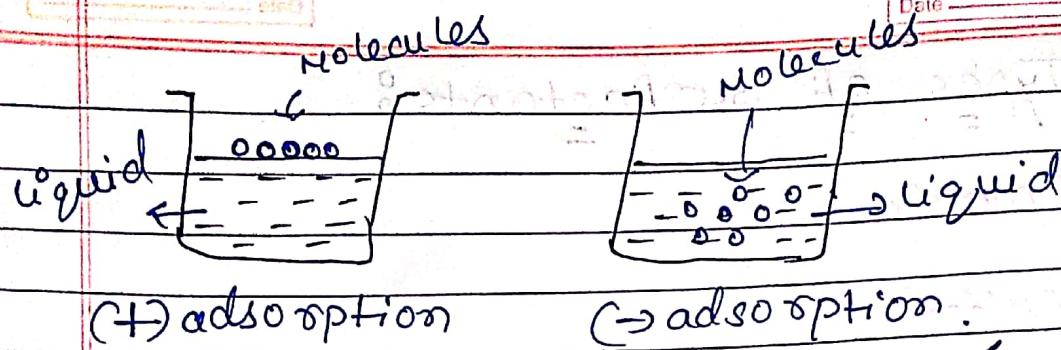
- deposition of molecules or ion on surface of liquid.

Negative adsorptn

- Molecules doesn't deposit on surface but it mix with liquid.

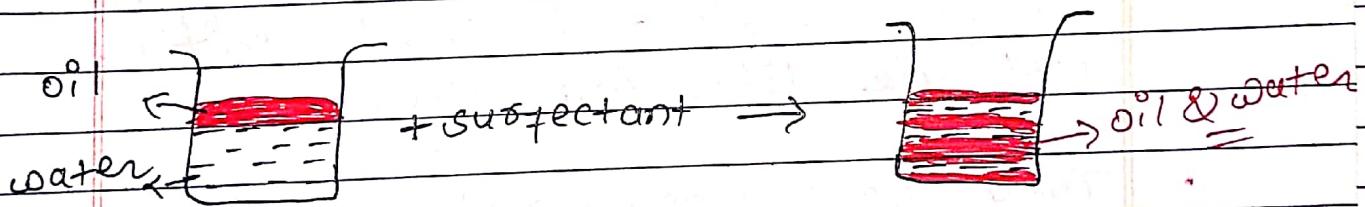
- surface free energy & surface tension \downarrow (dec.)

- surface free energy & surface tension \uparrow (inc.)



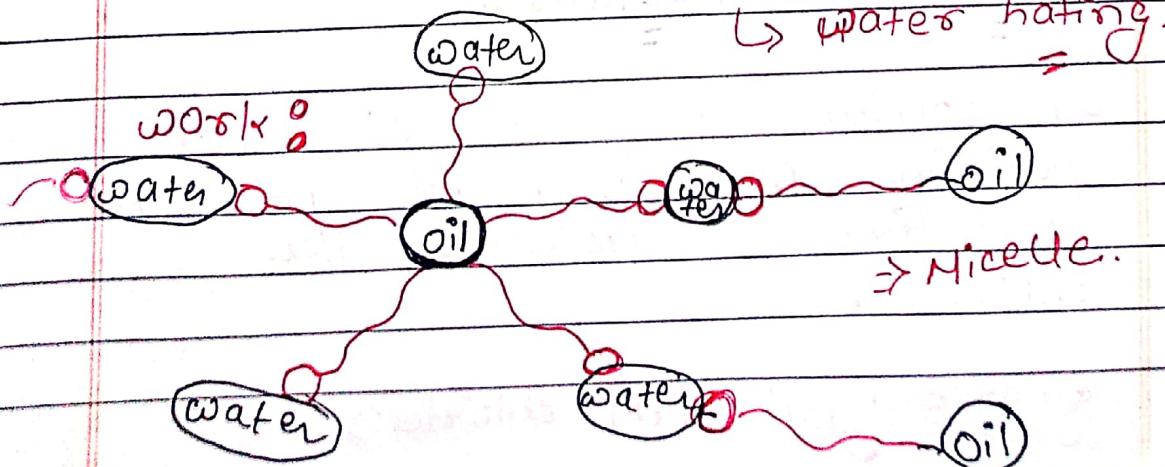
Surface Active Agents (Surfactants)

- These are the agents which reduced the surface tension and interfacial tension b/w two liquids.
- These agents are detergents, soaps, emulsifiers which help in mixing of immiscible liquid (oil into water).



(head) → hydrophilic nature
↑ water loving

(tail) → lipophilic / hydrophobic nature
↑ water hating



* Types of surfactants :

i) Anionic

ii) Cationic

iii) Ampholytic

iv) Non-ionic

* Anionic Surfactants :

- These are the most common type of surfactants.
- It contains organic tail with negative charge head and small positive molecule like Ammonia.
- They have unpleasant taste.
- eg \Rightarrow Alkali metals and ammonium soaps.

* cationic Surfactants :

- It contains organic tail with positive charge head and small negative molecule like chloride.
- eg \Rightarrow Benzethonium chloride.

* Non-ionic surfactants :

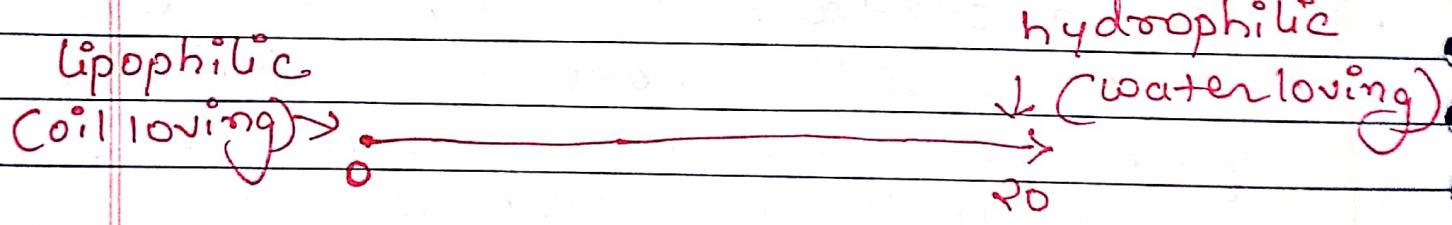
- They do not ionize in water because their hydrophilic part consists of non-dissociable molecules.
- They help to resist in pH change.
- Eg \Rightarrow glycerol.

* Amphoteric surfactants :

- They depends on the pH of the system.
- Below a certain pH they act as cationic while above a certain pH they are considered anionic & at intermediate pH they act as zwitter ionic.
 \hookrightarrow the net charge of the entire molecule is 0.
- Eg \Rightarrow Amino acetic acid.

HLB System : (Hydrophilic - lipophilic)
= Balance system

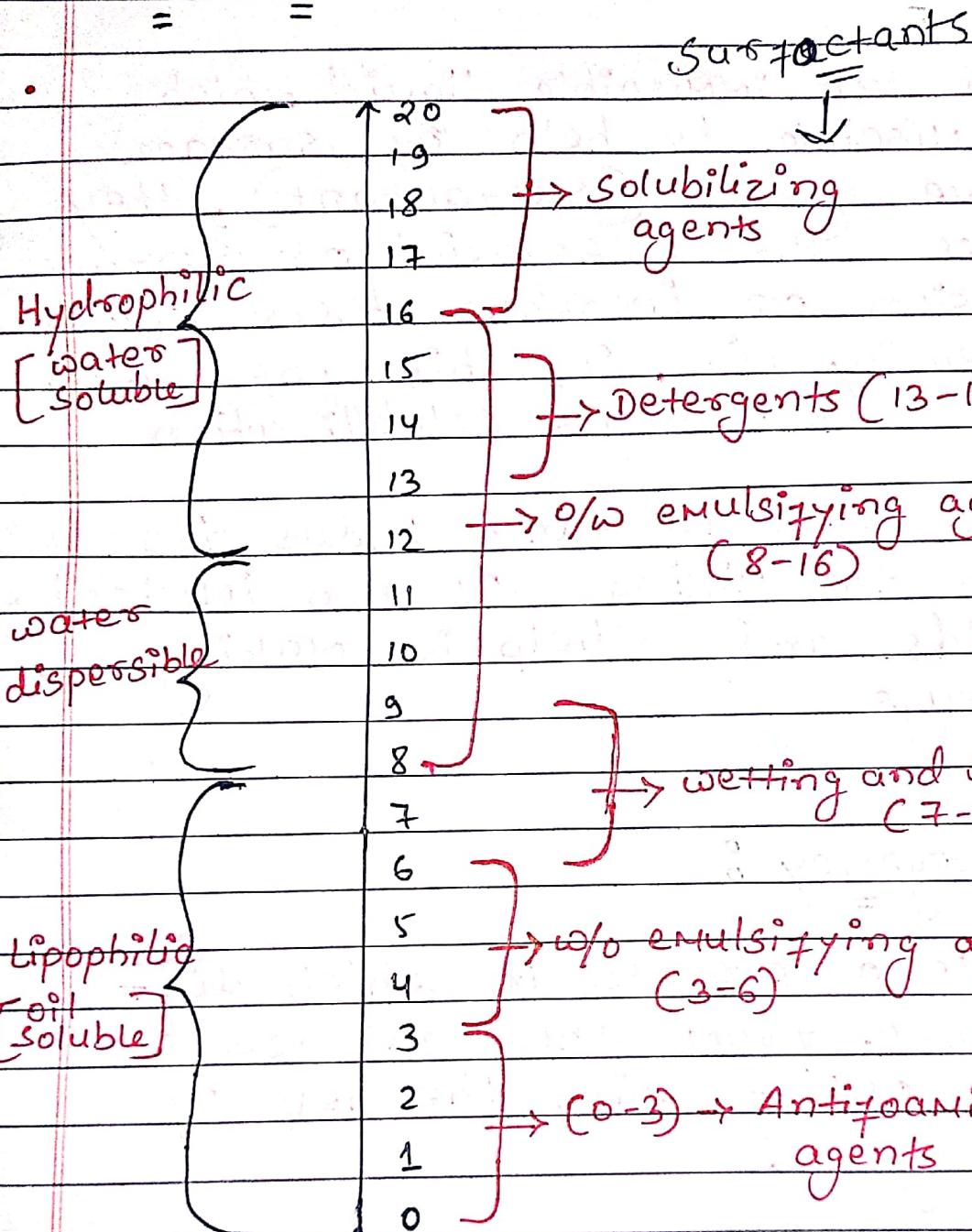
- HLB system consist of arbitrary scale in which values are assigned to different surfactants according to their nature.
- HLB value of 1 indicates:
 - Surfactant is lipophilic & soluble in oil.
- HLB value of 20 indicates:
 - Surfactant is hydrophilic & soluble in water.



$$\text{HLB} = \frac{\text{Hydrophilic}}{\text{Lipophilic}}$$

→ HLB Scale :

$$= \quad =$$



Solubilization :

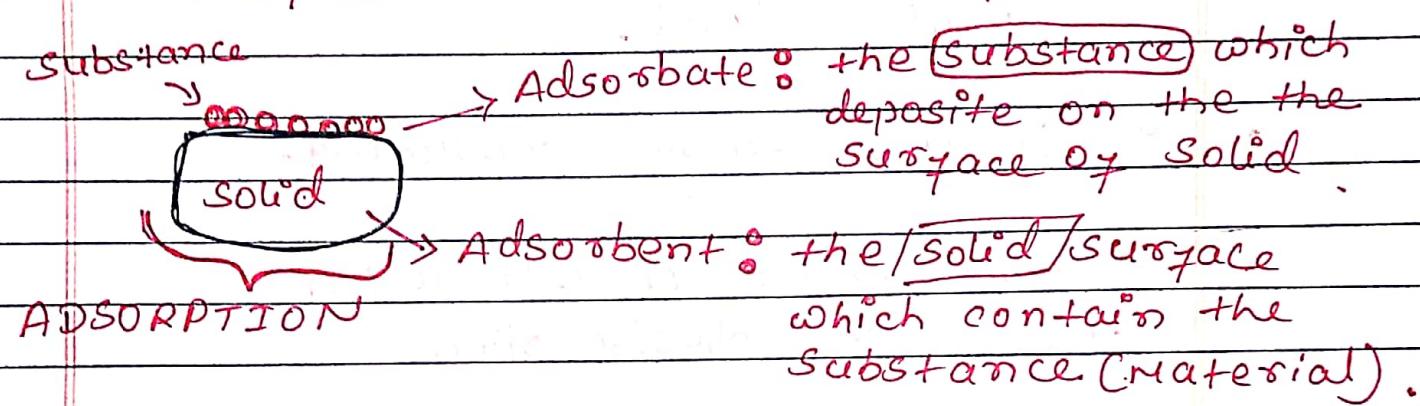
- In a two immiscible liquid which is miscible by help of surface active agents (surfactant), they reduce the interfacial or surface tension or increase their solubility to easily mix. So, this phenomena is known as solubilization.
- It is used in many industries for the mixing of two immiscible liquids and help in making drugs.

Detergency :

- It is a process in which dirt remove from the surface of an object with the help of detergent.
- And these detergent is made up of surfactant.
- It work that, it reduce the adhesive force, so dirt particle easily remove from the surface.

Adsorption at solid interface:

- when substance (material) deposites on the surface of solid is called the adsorption at solid interface.



- Now, adsorbent and adsorbate are attached with each other with some attraction forces.
- on the basis of attraction forces adsorption is divided into two types:

- i) physisorption (physical adsorption)
- ii) chemisorption (chemical adsorption).

→ physisorption:

- when adsorbent and adsorbate is attach with each other by some weak bonds like vanderwall force
- It is less energy consuming.
- weak force of attraction as compare to chemisorption.

→ chemisorption :

- when adsorbate and adsorbent are attached with each other by some strong chemical bond like as covalent O bond.
- It is more energy consuming.
- Strong force of attraction as compare to physisorption.