VIVEKANANDA COLLEGE

THAKURPUKUR

KOLKATA-700063

NAAC ACCREDITED ‘A’ GRADE

Topic:	Surface Tension
Course Title:	General Physical Chemistry
Paper:	BCMA CC3
Unit:	Biophysical Properties
Semester:	2
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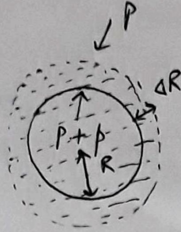
Name of the Department:	Biochemistry

• Excess pressure inside a liquid drop:



Let us consider a liquid drop of radius R on a liquid surface of surface tension T. The molecules on the surface of the drop experiences a net resultant force acting inwards due to surface tension.

∴ pressure inside the drop > pressure outside

This excess pressure inside produces an outward force which balance the surface tension & keeps the drop in equilibrium.

$P \rightarrow$ pressure outside the drop

$P+p \rightarrow$ " inside " "

∴ excess pressure $= p$.

Let this excess pressure push the surface of the drop slowly outwards by a distance ΔR. [ΔR is negligible for $P+p$ to change]

∴ mechanical work done by this excess pressure

$$W = F \times \text{displacement}$$

$$= \text{pressure} \times \text{area} \times \text{displacement}$$

$$= p \times 4\pi R^2 \times \Delta R$$

∴ increase in surface area $= \Delta A = 4\pi(R+\Delta R)^2 - 4\pi R^2$

$$= 4\pi[R^2 + 2R\Delta R + (\Delta R)^2] - 4\pi R^2$$

$$= ~~8R\Delta R~~\ 8\pi R\Delta R$$

[$\Delta R^2 \rightarrow$ neglected]

∴ increase in surface energy $= 8\pi R\Delta R \times T$.

Now, $p \times 4\pi R^2 \Delta R = 8\pi R\Delta R \times T$

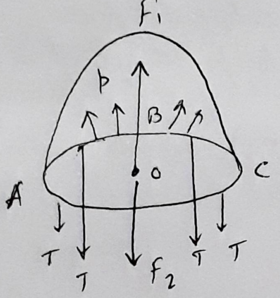
$$\Rightarrow \boxed{p = \frac{2T}{R}}$$

· Excess pressure in a spherical soap bubble:

→ Spherical soap bubble has 2 surfaces — inner & outer.

→ Molecules on both surfaces experience an inward force due to surface tension.

→ The spherical shape is maintained by the excess pressure inside the bubble which is equal & opposite to the surface tension.



r = radius of spherical bubble

p = excess internal p

T = S.T. of soap solution

A spherical bubble is divided into 2 hemispheres by a horizontal plane ABC.

Area of ABC $= \pi r^2$

Upward force due to excess pressure $= p \times \pi r^2 = F_1$

Downward force acts all along the circumference.

$F_2 = 2 \times 2\pi r T$ (∵ the bubble has 2 surfaces)

At eq, $F_1 = F_2 \Rightarrow$ ~~$2 \times 2\pi r T$~~

$$2 \times 2\pi r T = p \times \pi r^2$$

$$\Rightarrow \boxed{p = \frac{4T}{r}}$$

$$\boxed{\Delta P = \frac{4S}{r}}$$

If π = atmospheric pressure, then total pressure inside the bubble

$$P = \pi + \frac{4T}{r}.$$

• Interfacial tension:

Occurs in the interface / surface of 2 ~~[illegible]~~ immiscible liquids in contact with each other. Defined in a way similar to surface tension. It is the force acting along the surface perpendicular to any line of unit length.

The interfacial tension (γ_{AB}) between 2 liquids A & B is equal to their difference in respective surface tensions γ_A & γ_B.

i.e. $\gamma_{AB} = | \gamma_A - \gamma_B |$

• Surface active reagents / Surfactants: eg soap

Have a general tendency of accumulating at the surface. They act as detergents having the capability of lowering the interfacial tension between water & dirt / grease and renders wetting of grease easier. Grease is not readily wetted by water. Thus surfactants help in wetting of grease by water & remove them.

(micelle } → consult standard text)
cmc }

• The variation of surface tension of a solvent on addition of a solute is given by Gibb's Adsorption Isotherm.

$$\Gamma_2 = -\frac{c}{RT}\frac{d\gamma}{dc}$$

Γ_2 → Excessive concentration of solute at the surface wrt the bulk of the solution

If $d\gamma$ = ⊖ve, Γ_2 = ⊕ve

= ⊕ve, Γ_2 = ⊖ve.

For soap, Γ_2 = ⊕ve and hence $d\gamma$ = ⊖ve i.e there occurs a decrease in the surface tension of water on addition of detergents.

NaCl, KCl, etc, have more concentration at the bulk of the solution, rather than on the surface [~~⊕~~ ~~⊖ve~~] [Γ_2 = ⊖ve] and thus increases the γ for water.

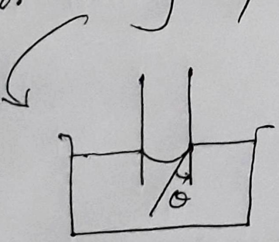
- Capillary action:

The rise or fall of a liquid in a capillary tube, when it is dipped in the liquid, is called capillary action. This is a direct consequence of the surface tension of the liquid.

→ Wetting liquids:

Adhesive forces between the liquid & the solid capillary surface are higher than the ~~adh~~ cohesive forces between the liquid molecules. As a result, the liquid has a tendency to spread on the solid surface and its meniscus is concave upwards. These liquids tend to rise up in the capillary tube.

The angle of contact, measured within the liquid from the side of the tube to the tangent drawn along the meniscus touching the surface of the tube, is acute ~~an~~ (< 90°) in this case for wetting liquids.



Wetting Liquids

In the other case, where the cohesive forces are greater than the adhesive forces, the liquid detaches from the surface of the solid. The angle of contact is obtuse (> 90°) and the meniscus of such a liquid is convex upwards and the liquid level falls in the capillary.