بسم الله الرحمن الرحيم

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وَفَوْقَ كُلِّ ذِي عِلْمٍ عَلِيمٌ

صدق الله العظيم

سورة يوسف أيه 76

Basic Chemistry for Engineering

Surface tension of liquids

"It is the work (erg. cm^{-2}) require for increase the surface area of liquid 1 cm^2" Or " It is the force (dyne .cm -1) require for increase the liquid surface are"

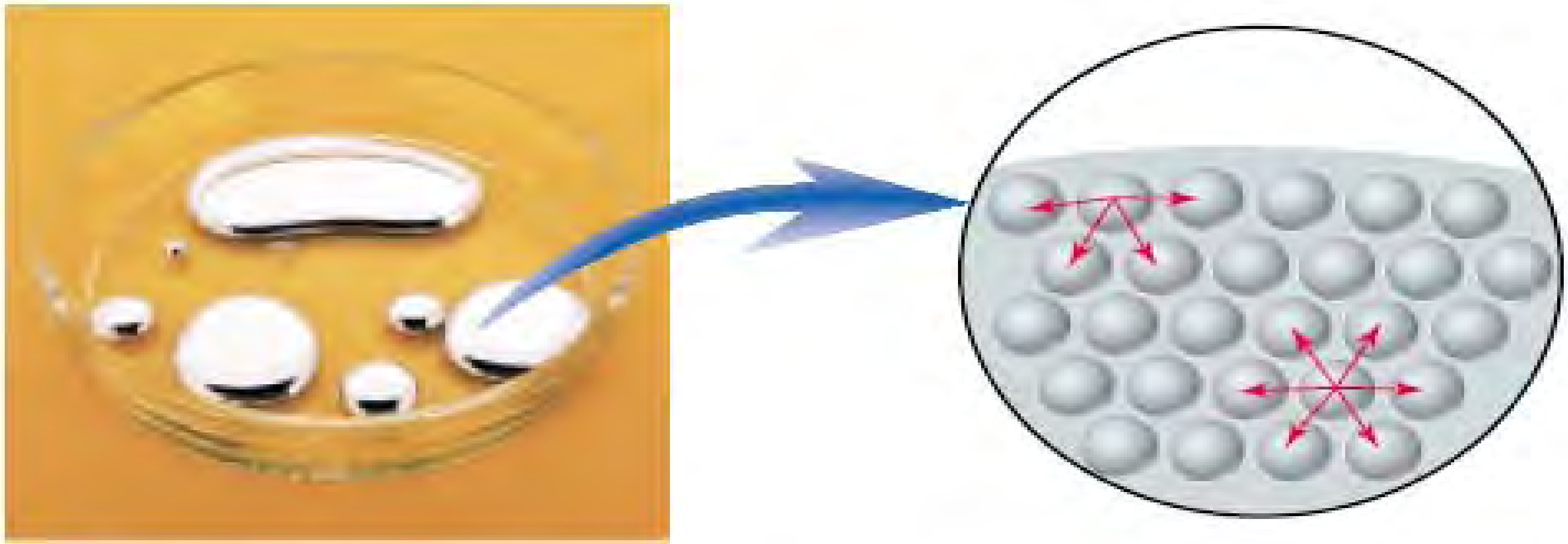
*** Explanation of the surface tension phenomena**

"The molecules inside the liquid affected by the attraction forces (inside the liquid) this forces are equilibrium in all direction: But in the surface layer of the liquid, the attraction forces are not equilibrium in all directions, so the surface layer will be in tension state and affected by surface tension forces". Thus the liquids surfaces try to decreasing its area to decrease this surface tension (by taking the ball or the drop shape).

Data for some common substances are given in Table 10.6. Note that mercury has a particularly large surface tension, causing droplets to form beads (Figure 10.8) and giving the top of the mercury column in a barometer a particularly rounded appearance.

The surface tension of water supports this water strider. The nonpolar surfaces of its feet also help to repel the water.

Droplets of mercury lying on a glass surface. The small droplets are almost spherical, whereas the larger droplets are flattened due to the effects of gravity. This shows that surface tension has more influence on the shape of the small (lighter) droplets.



▲ **FIGURE 10.8** Surface tension, which causes these drops of liquid mercury to form beads, is due to the different forces experienced by molecules in the interior of a liquid and those on the surface. Molecules on the surface feel attractive forces on only one side and are thus drawn in toward the liquid.

TABLE 10.6 Viscosities and Surface Tensions of Some Common Substances at 20°C

Name	Formula	Viscosity ($N \cdot s/m^2$)	Surface Tension (J/m^2)
Pentane	C_5H_{12}	2.4×10^{-4}	1.61×10^{-2}
Benzene	C_6H_6	6.5×10^{-4}	2.89×10^{-2}
Water	H_2O	1.00×10^{-3}	7.29×10^{-2}
Ethanol	C_2H_5OH	1.20×10^{-3}	2.23×10^{-2}
Mercury	Hg	1.55×10^{-3}	4.6×10^{-1}
Glycerol	$C_3H_5(OH)_3$	1.49	6.34×10^{-2}

Classification of liquids according to its surface tension

I . High surface tension liquids

☑The attraction forces between the solid surface (capillary tube) and the liquid molecules are greater than the attraction forces between the liquid molecules. So; the liquid will be goes up as in the figure.

II. Low surface tension liquids

☑The attraction forces. Between the liquid molecules are greater than the attraction forces between the solid surface (capillary tube) and the liquid molecules. So, the Liquid will be goes down as in the figure.

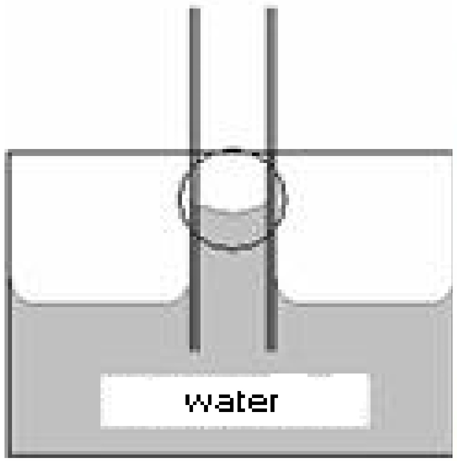


Figure 13-9 The meniscus, as observed in glass tubes with water and with mercury.

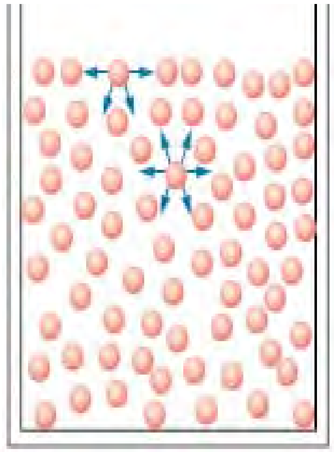
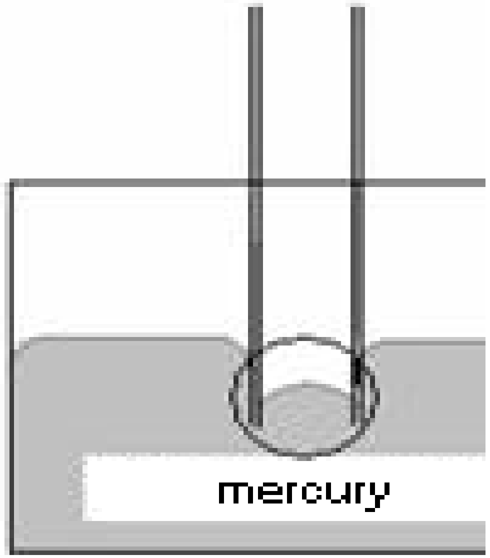
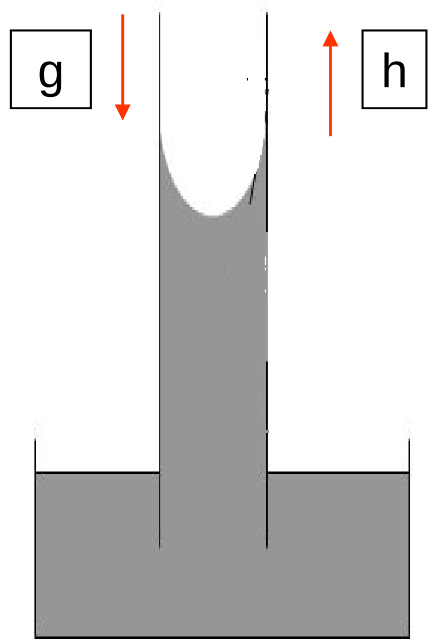


Figure 13-8 A molecular-level view of the attractive forces experienced by molecules at and below the surface of a liquid.



Method of measuring the surface tension (Capillary – rise method) :

$$\text{Surface tension} (\sigma) = \frac{rhdg}{2}$$



r (radious) $= cm$
h (high) $= cm$
g (acceleration) $= cm\ Sec^{-2}$
d (density) $= gm\ cm^{-3}$
$= dyne . cm^{-1}$

Ex. Acetone liquid goes up in capillary tube at 5.12 cm, the radius of the capillary tube is 0.0117cm and the density of acetoneis0.79gm.Cm-3.

Calculate the surface tension of acetone.

$$= \frac{rhdg}{2}$$

$$= ½ \ x\ 0.0117\ x\ 5.12\ x0.79\ x981$$

$$=23.2\ \text{dyme}\ .\text{cm}^{-1}.$$

the emulsifiers is materials using. for decrease.

The surface tension of the liquids.

It consists of two parts.

1-Hydrocaroon chain (non polar)

2- Function group (polar).

And it is using for:

1. Elimination the fats from the clothes by decreasing the surface tension between the water and the fats.
2. Decrease the surface tension between the plant surface and pesticides.
3. Control of mosquitoes by decreasing the surface tension of water surface using oils.
4. Decrease the surface tension of the sea waves using oils.
5. Decrease the surface tension between the food and container surface using oils.

Viscosity

- We all know, for instance, that some liquids, such as water or gasoline, flow easily when poured, whereas others, such as motor oil or maple syrup, flow sluggishly.
- The measure of a liquid's resistance to flow is called its **viscosity. Not surprisingly,** viscosity is related to the ease with which individual molecules move around in the liquid and thus to the intermolecular forces present. Substances with small non polar molecules, such as pentane and benzene, experience only weak intermolecular forces and have relatively low viscosities, whereas more polar substances, such as glycerol [C3H5 (OH)3] experience stronger intermolecular forces and so have higher viscosities.

Viscosity, is generally higher in liquids that have stronger intermolecular forces. properties are also temperature-dependent because molecules at higher temperatures have more kinetic energy to counteract the attractive forces holding them together. As temperature increases and the molecules move more rapidly, their kinetic energies are better able to overcome intermolecular attractions. Thus, viscosity decreases with increasing temperature, as long as no changes in composition occur.

▲ Less viscous liquids like water flow freely when poured, while more viscous liquids like motor oil flow sluggishly.

Viscosity

" It can be defined as the resistance of liquid when its layers flowing through solid surface"

ex. "Water" : Flow in fast through the solid surface comparing to "oils" flow in slowly this due to its viscosity.

$$\text{Viscosity} = \frac{\text{Forces x Distance between layers}}{\text{Velocity X Area}}$$

$$= \frac{\text{dyne x cm}}{\text{cm / sec X cm}^2}$$

$$= \frac{\text{dyne / sec}}{\text{cm}^2}$$

$$= \frac{\frac{\text{gm x cm}}{\text{sec}^2} \text{ x Sec}}{\text{cm}^2}$$

$$= \frac{\text{gm}}{\text{cm x sec}}$$

* The viscosity calculate by “ Viscosity coefficient”.

•There is an irreversible relationship between the viscosity and the liquid velocity.

Ex. Oils and Glycerin has “High viscosity coefficient” while Benzene, Water and Alcohols has “ low viscosity coefficient” .

The symbol of the viscosity coefficient is “eta η its unit is (Poise)

η Of H_2O at 25 ^oC = 0.00895 poise.

The measurement of the liquids viscosity by “Viscometer” according to the equation:

$$\eta = \frac{\Pi\, h d g\, r^4 t}{8\, V L}$$

Π = constant (3.14)
L = Length of the capillary tube
T = time of flowing
d = liquid density

V = volume
r = radius
h = liquid high
g = acceleration

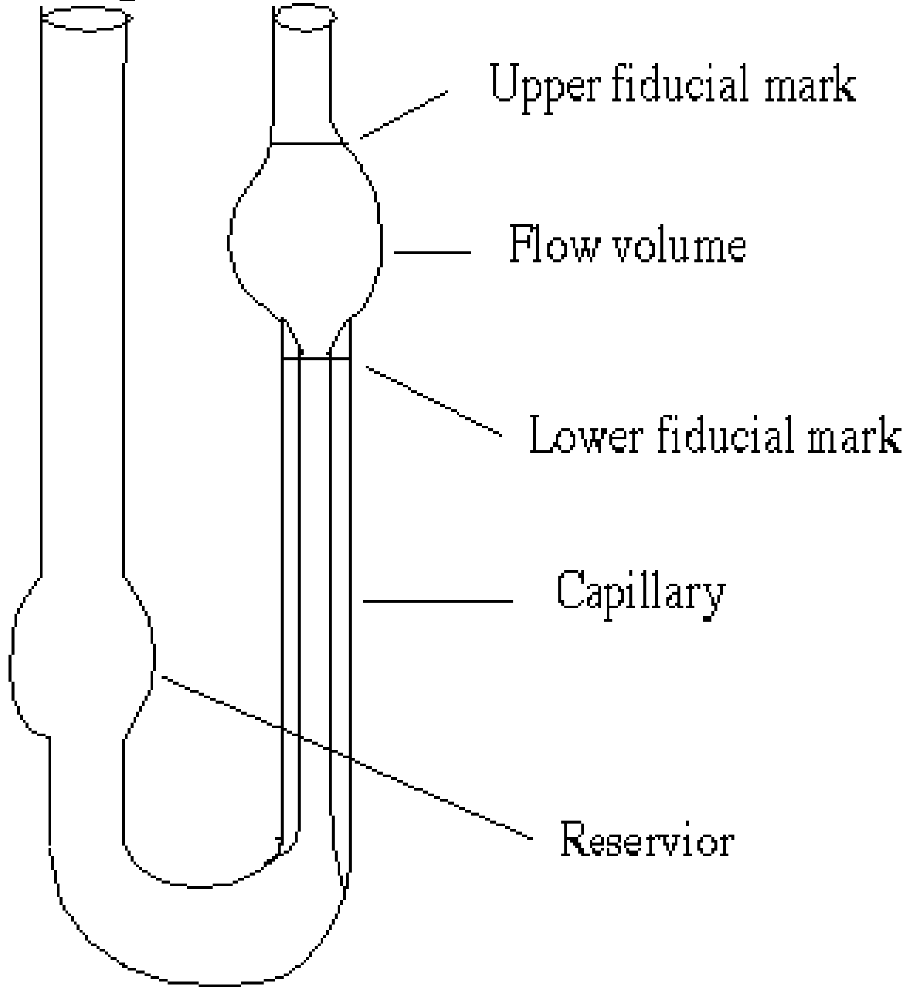
☑ There is an easier way to measuring the liquids viscosity by " ostwald viscometer according to the equation:

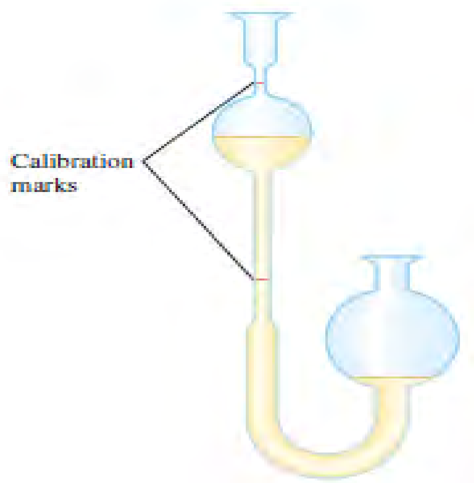
$$\frac{\eta_1}{\eta_2} = \frac{d_1 t_1}{d_2 t_2}$$

η_1 = viscosity coefficient of unknown liquid .
η_2= viscosity coefficient of standard liquid (H2O)

d_1= density of unknown liquid.
d_2= density of water.

t_1= Flow time of unknown liquid.
t_2= Flow time of water.





The Ostwald viscometer, used to measure viscosity of liquids. The time it takes for a known volume of a liquid to flow through a small neck of known size is measured. Liquids with low viscosities flow rapidly.

ex. The heptane's flowing in Ostwald viscometer at 64 sec while the water is flowing at 108 sec at the same conditions. Calculate the viscosity of Heptane

If : density of water = 1 (at 25 ^oC).

: density of Heptane = 0.689.

: Viscosity of water = 0.01 Poise .

$$\frac{\eta_1}{\eta_2} = \frac{d_1 t_1}{d_2 t_2}$$

$$\frac{\eta_1}{0.01} = \frac{0.689 \times 64}{1 \times 108}$$

$$\eta_1 (\text{Heptane}) = 0.00412 \text{ Poise}$$


Thank You