UNIT-V (INTRODUCTORY PHYSICS)

Definition

The surface tension of a liquid is mainly a force that mainly acts to reduce the surface area of a liquid. The directed contracting force which attracts the molecules at the surface of a liquid towards the interior of the liquid is surface tension. The surface tension of liquids depends on the composition of the vapour phase.

There are two primary mechanisms in play.

- Inward force on the surface molecules causing the liquid to contract
- Tangential force parallel to the surface of the liquid.

Unit of Surface Tension

SI Unit	N/m
CGS Unit	dyn/cm

Dimension of Surface Tension

surface tension is given by the formula,

Surface tension = F/L

We know that F = ma, substituting the value in the equation, we get

=ma/L

Equating the fundamental quantities into the equation, we get

$=MLT^{-2}L^{-1}$

Solving further, we get

$=\mathbf{MT^{-2}}$

Hence, the dimensional formula of surface tension is $\mathbf{MT^{-2}}$.

Properties

1) Surface tension is a scalar quantity

2) It acts tangential to liquid surface

3) Surface tension is always produced due to cohesive force

4) More is the cohesive force more is the surface tension

Examples of Surface Tension

- Insects walking on water.
- Floating a needle on the surface of the water.
- Rainproof tent materials where the surface tension of water will bridge the pores in the tent material.
- Clinical test for jaundice.
- Surface tension disinfectants (disinfectants are solutions of low surface tension).

Surface tension of various liquids

Liquid	Surface Tension (N/m)
Hydrogen	2.4
Helium	0.16
Water	0.072
Ethanol	22.0
Sodium Chloride	114

Methods of Measurement

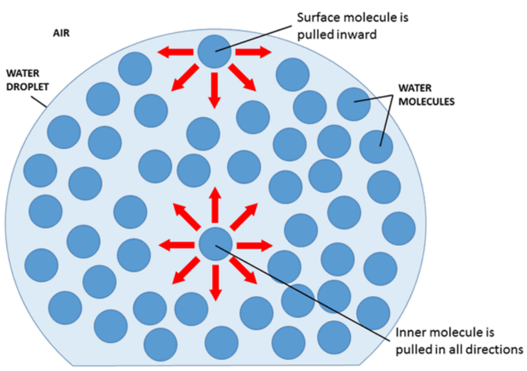
- Spinning drop method
- Pendant drop method
- Capillary rise method
- Bubble pressure method
- Resonant oscillations of a spherical and hemispherical liquid drop
- The vibrational frequency of levitated drops
- Sessile drop method

Shape of liquid drop

Surface tension is responsible for the shape of liquid droplets. Although easily deformed, droplets of water tend to be pulled into a spherical shape by the cohesive forces of the surface layer. In the absence of other forces, including gravity, drops of virtually all liquids would be approximately spherical.

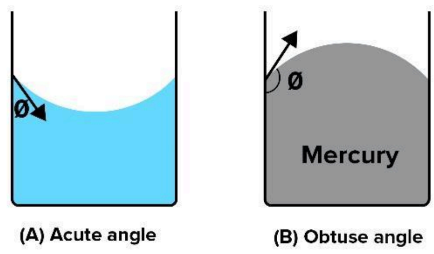
The spherical shape of water:

- Because of a phenomenon known as surface tension, water drops, or any other liquid's drops, are spherical in shape.
- This acts on the surface of a freely falling drop in a liquid to reduce its area.
- In comparison to other things, such as an ellipsoid (an egg-shaped object), the ratio of surface area to volume in the case of a sphere is the smallest.
- Spherical shapes have less potential because they can withstand any external force in the atmosphere.
- Water forms a spherical shape because of its **surface tension.**



Angle of Contact

1. It is defined as the angle subtended between the tangents drawn at the liquid surface and the solid surface inside the liquid at the point of contact .
2. The angle of contact is determined by the nature of the liquid, the solid with which it comes into contact, and the medium that exists above the liquid's free surface.
3. The angle of contact increases as the temperature of the liquid rises.
4. When soluble impurities are added to a liquid, the angle of contact decreases.



The angle of contact is influenced by intermolecular forces between the liquid, solid, and surrounding medium. It can be classified into three categories:

Wetting

If the liquid spreads over the solid surface and wets it effectively, forming a relatively flat contact area, the angle of contact is less than 90 degrees. This is referred to as a small or acute angle of contact. The liquid is said to be wetting the solid surface.

Non-wetting

If the liquid forms a droplet on the solid surface and does not spread, resulting in a large angle of contact greater than 90 degrees, it is referred to as a non-wetting or a large angle of contact. The liquid does not effectively wet the solid surface.

Partial Wetting

In some cases, the liquid wets the solid surface to a certain extent, but not completely. The angle of contact falls between 0 and 90 degrees, indicating partial wetting.

The angle of contact plays a significant role in various scientific and practical applications. It affects phenomena such as adhesion, surface tension, capillary action, and the behavior of droplets on surfaces. Understanding and controlling the angle of contact is crucial in fields such as materials science, surface chemistry, surface coating, and fluid dynamics.

Characteristics of Angle of Contact

Wetting Behavior	**Angle of Contact**	**Characteristics**
Wetting	Less than 90°	The liquid spreads over the solid surface, forming a relatively flat contact area. It indicates good adhesion and surface wetting
Non-Wetting	Greater than 90°	The liquid forms a droplet on the solid surface, not spreading effectively. It shows poor adhesion and surface repelling.
Partial Wetting	Between 0° and 90°	The liquid wets the solid surface to some extent but not completely. It exhibits a combination of wetting and non-wetting characteristics.

<u>Viscosity Definition</u>

Viscosity is a measure of a fluid's resistance to flow.
The SI unit of viscosity is poiseiulle (PI). Its other units are newton-second per square metre ($N\ s\ m^{-2}$) or pascal-second (Pa s.) The dimensional formula of viscosity is $[ML^{-1}T^{-1}]$.

The viscosity of liquids decreases rapidly with an increase in temperature, and the viscosity of gases increases with an increase in temperature. Thus, upon heating, liquids flow more easily, whereas gases flow more slowly. Also, viscosity does not change as the amount of matter changes, therefore it is an intensive property

Viscosity Formula

$$\eta = \frac{2ga^2(\Delta\rho)}{9v}$$

. Where $\Delta\rho$ is the density difference between fluid and sphere tested, a is the radius of the sphere, g is the acceleration due to gravity and v is the velocity of the sphere.

Viscosity Types

Viscosity is the measure of fluid's friction to its flow. There are two ways to measure the fluid's viscosity as follows:

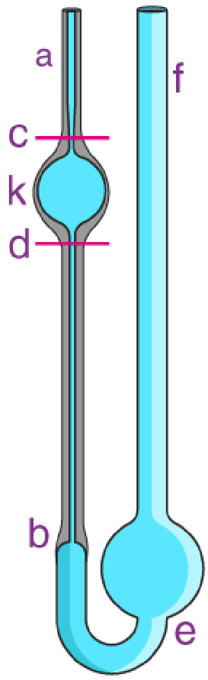
- Dynamic Viscosity (Absolute Viscosity)
- Kinematic Viscosity

Viscosity Measurement

U-Tube Viscometer

U-tube viscometers are also known as glass capillary viscometers or Ostwald viscometers.

A viscometer consists of two reservoir bulbs and a capillary tube. In one arm of the U is the capillary, a vertical section of a precise narrow bore. Above, which is a bulb, and with it is another bulb lower down on the other arm, as shown in the image.



In use, the upper bulb draws the liquid by suction, and then the liquid is made to flow down through the capillary into the lower bulb. Two marks (one above and one below the upper bulb) indicate a known volume. The time taken for the liquid to pass between these marks is proportional to the kinematic viscosity.

Most commercial units are provided with a conversion factor. The time taken by the test liquid to flow between two points is measured. By multiplying the time measured by the factor of the viscometer, the kinematic viscosity is obtained.

Lubricant

1. A lubricant is a substance that helps to reduce friction between any two adjacent surfaces in mutual contact,
2. Which ultimately reduces the heat generated when the surfaces move.
3. Generally, they are used wherever a single surface is moving or both are moving.
4. It may also have the function of transmitting forces, transporting foreign particles, or heating or cooling the surfaces

Qualities of a good lubricant:

1. The main quality of a good lubricant is that it must possess a very high viscosity.
2. This helps the mechanical parts work better when lubricants are applied to a machine.
3. The slope of the lubricant with a high viscosity is more horizontal, and the viscosity remains more stable across a wider temperature range.
4. This means a lubricant with a higher viscosity index is more desirable because it provides a more stable lubricating film over a wider temperature range.
5. The higher the viscosity of the lubricants the greater their ability to provide boundary lubrication, which means lubrication of the boundary between moving parts.

Hence, a good lubricant must have high viscosity.

Capillary flow/Capillary action

Tubes having very small diameters (narrow cylindrical tubes) are called capillary tubes. If these narrow tubes are dipped in a liquid, it is observed that the liquid in the capillary either rises or falls relative to the surrounding liquid level. This phenomenon is called **capillary action,** and such tubes are called capillary tubes.

Liquid Meniscus in Capillarity

In capillarity, the liquid meniscus can be:

(i) concave meniscus

(ii) convex meniscus

(iii) plane meniscus

Diffusion

Diffusion is the process of movement of molecules under a concentration gradient. It is an important process occurring in all living beings. Diffusion helps in the movement of substances in and out of the cells. The molecules move from a region of higher concentration to a region of lower concentration until the concentration becomes equal throughout.

Types of Diffusion

Simple diffusion

Facilitated diffusion

Factors affecting Diffusion

There are a few factors that affect the process of diffusion, which individually and collectively alters the rate and extent of diffusion. These factors include:

- Temperature.
- Area of Interaction.
- Size of the Particle.

- The steepness of the concentration gradient.

Examples of Diffusion

- A tea bag immersed in a cup of hot water will diffuse into the water and change its colour.
- A spray of perfume or room freshener will get diffused into the air by which we can sense the odour.
- Sugar gets dissolved evenly and sweetens the water without having to stir it.

Conductors

an electrical conductor is defined as materials that allow electricity to flow through them easily. This property of conductors that allow them to conduct electricity is known as *conductivity*.

The flow of electrons in a conductor is known as the *electric current*. The force required to make that current flow through the conductor is known as *voltage*.

Examples of conductor

Graphite, the human body, and the earth are good conductors of electricity. Some of the common conductor examples include metals such as:

- Copper
- Gold
- Iron

Insulators are materials that hinder the free flow of electrons from one particle of the element to another. If we transfer some amount of charge to such an element at any point, the charge remains at the initial location and does not get distributed across the surface.

Examples of insulators

Some of the common insulator examples are given below:

- Plastic
- Wood
- Glass

Differences between Conductor and Insulators

Conductor	Insulator

Materials that permit electricity or heat to pass through it.	Materials that do not permit heat and electricity to pass through it.
A few examples of a conductor are silver, aluminium, and iron.	A few examples of an insulator are paper, wood, and rubber.
Electrons move freely within the conductor.	Electrons do not move freely within the insulator.
The electric field exists on the surface but remains zero on the inside.	The electric field doesn’t exist.