→ A physical property is any property that is **measurable**, whose value describes a state of a physical system. In this types of properties include state of matter, colour, odour etc.

→ Molecular structure describes the **location of the atoms**, not the **electrons**.

Learning Objective

→ Difference between physical and chemical properties with examples.

→ Classify different types of physical properties.

→ Be able to measure different physical properties like surface tension, viscosity, refractive index and optical activity.

→ Explain new physical properties such as **Molar volume** and **Paracheor** very useful to determine the molecular structure.

Types of Properties

→ **Physical Property:** The measurement of a physical property may change the arrangement of matter in a sample, but not structure of its molecules. For eg. Colour, melting point, boiling poin etc.

→ **Chemical Property:** The change of one type of matter into another type (or the inability to change) is a chemical property. Examples of chemical properties include **flammability**, **toxicity**, **acidity**, **reactivity (many types**), **heat of combustion**, etc.

→ **Extensive Property:** If the property depends on the amount of matter present, it is an extensive property. For eg. mass, volume, heat capacity etc.

→ **Intensive property:** If the property of a sample of matter does not depend on the amount of matter present, it is an intensive property. For eg. **density**, **temperature, molar heat capacity**.

→ **Qualitative properties:** Qualitative properties are properties that are observed and can generally not be measured with a numerical result but it can be determined by chemical test. For eg. Determination of unknown organic compound in laboratory.

→ **Quantitative properties:** Quantitative properties which have numerical characteristics. For eg. . Determination of concentration of sample by volumetric analysis.

Types of Physical Properties

→ **Additive Properties:** Additive properties are those properties which is the **sum of the corresponding properties of the atoms** constituting the molecule. These properties only depend on the types of the atom and their numbers e.g., **mass** is a additive property, similarly **molar volume** is also a good example of additive properties.

→ **Colligative Properties:** Colligative properties are those properties, which depends upon the **number of molecules** present in a substance e.g., **osmotic pressure** of the solution, **pressure of gas**,**elevation in boiling point** etc.

→ **Constitutive Properties:** Constitutive property of a molecule is the property which depends upon the **constitution of the molecule**, i.e., upon the **arrangements of atoms** within the molecule e.g.**optical activity.**

→ **Additive and Constitutive Properties:** The physical property which depend upon the **number of atom in a molecule as well as their constitution**, is known as additive and constitutive properties.e.g., **atomic volume**, **parachor** etc.

Short Questions /Blanks

1. Parachor is additive and constitutive Properties.

2. Density and temperature are intensive property.

3. Colour of any matter is physical property.

Molar Volume

→ Molar Volume, symbol Vm, of a substance is the occupied volume divided by the amount of substance at a given temperature and pressure. It is equal to the **molar mass (M)** divided by the **mass density (ρ)**

Formula

$$V_m = \frac{M}{\rho}$$

V_m = molar volume
M = molar mass
ρ = mass density

Surface tension

- → "Surface tension is the tension of the surface film of a liquid caused by the attraction of the particles in the surface layer by the bulk of the liquid, which tends to minimise surface area".
- → **Symbol:** ϒ (read **gamma)**
- → **Unit:** N/m

<u>**Examples of Surface Tension**</u>

(i) Floating a Needle: If we place a small needle on the surface of water, it can flot on the surface of water even though it is several times as dense as water. If the surface is agitated to break up the surface tension, than needle will quickly sink.

(ii) Walking on Water: Small insects such as the water strider can walk on water because their weight is not enough to penetrate the surface.

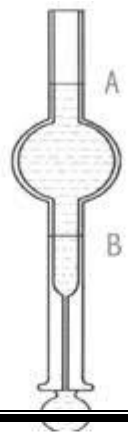
(iii) Cleaning of Clothes: Soaps and detergents help the cleaning of clothes by lowering the surface tension of the water so that it more readily soaks into pores and soiled areas.

Name of method to determine Surface tension

1. The Capillary Rise method.
2. Drop formation method.
3. The Drop weight method.
4. The ring method.

The Drop weight method

- → It is **quite convenient** and **accurate methods**.
- → The apparatus used as **Stalagnometer**.
- → When the liquid is allowed to pass through drop by drop through capillary tube held vertically, every drop coming out of the capillary tube grows **spherically in size** and attain some **definite weight**.



Surface tension ∞ Weight of the drop

$$\frac{\gamma 1}{\gamma 2} = \frac{d1n1}{d2n2}$$

Stalgnometer

→ Density and number of drops of same volume of liquid can be determined practically, if the surface tension of one liquid is known, the surface tension of other liquid can be calculated.

Parachor

Parachor defined as the " **molar volume of a liquid at definite temperature, when its surface tension unity". OR " molar volume of a liquid at unit surface tension is known as Parachor.**

- → **Symbol :** P
- → **Unit :** unit less
- → **Equation of Parachor , P = $V_m \Upsilon^{1/4}$**

- → The value of Parachor given in below table.

C	**H**	**CH3**	**CH2**	**i-Pr**	**2-Bu**
9	15.5	55.5	40	133.3	171.9
i-Bu	**t-Bu**	**Pnenyl**	**COO**	**COOH**	**OH**
173.3	170.4	189.6	63.8	73.8	29.8
NH2	**O**	**NO2**	**NO3**	**CONH2**	**C=O**
42.5	20	74	93	91.7	22.3
CHO	**S**	**P**	**F**	**Cl**	**Br**
66	49.1	40.5	26.1	55.2	68
I	**TtipleBond**				
90.3	40.6				

Short Questions/Blanks

1. Molar volume represented by - V_m

2. What is SI unit of Surface tension? - N/m

3. Give the equation of Parachor ? – P = $Vm\Upsilon^{1/4}$

4. Write name of apparatus used for surface tension determine - Stalagnometer

Viscosity

→ Viscosity is a measure of a **fluid's resistance** to flow. It describes the **internal friction** of a moving fluid. A fluid with large viscosity resists motion because its molecular make up gives it a lot of internal friction.

→ A fluid with **low viscosity** flows easily because its molecular makeup results in very little friction when it is in motion.

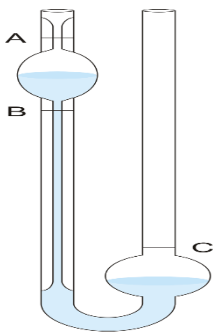
→ **Symbol: η** (read **eta)**
→ **Unit:** gm.$cm^{-1}sec^{-1}$ OR Poise (P)
→ The reciprocal of viscosity is term called as **Fluidity** and is denoted by ϕ
→ **Viscosity equation :** $\frac{\boldsymbol{F}}{\boldsymbol{A}} * \frac{dx}{dv}$

Factor effect on Viscosity

→ **Temperature:** Viscosity decrease with increasing of temperature because of average **intermolecular forces decrease**. **Honey and syrup** are examples of viscosity low at high T.
→ **Pressure:** Generally viscosity independent of pressure, since liquid are normally **incompressible** in nature.

Determination of Viscosity: *Ostwald Viscometer*

→ **Wilhelm Ostwald** was developed Ostwald Viscometer.



Ostwald Viscometer

→ The method of determining viscosity with this instrument consists of measuring the time for a known volume of the liquid (the volume contained between the marks A and B) to flow through the capillary under the influence of gravity.

→ A definite volume of liquid (say 25 mL) is poured into the **bulb C** with the use of pipette.

→ Now liquid is sucked up to mark-A of the left-limb with the help of rubber tube. Then the liquid is released to flow down up to **mark-B**. Note the time (t_1) for the liquid release from A to B mark with the use of **stopwatch.**

→ The density of liquid (d) and water density (dw) are determined with the help of a **Picknometer** or **specific gravity bottle**.

$$\frac{\eta 1}{\eta 2} = \frac{dt1}{dwt2}$$

Where η = co-efficient viscosity of liquid,
ηw = co-efficient viscosity of water,
d = density of liquid,
dw = density of water,
t_1 = time of flow for liquid,

t_2 = time of flow for water,

Refractive Index (RI)

→ When a ray of light passes from one medium into another its direction changed is known as **Refraction**.

→ In optics, the refractive index (also known as **refraction index** or **index of refraction**) of a material is a dimensionless number that describes how fast light travels through the material

→ **Snell's law** states that the ratio of the **sines** of the angles of **incidence** and **refraction** is equivalent to the ratio of phase velocities in the two media, or equivalent to the reciprocal of the ratio of the indices of refraction

$$\eta = \frac{\sin i}{\sin r}$$

Where i = angle of incidence
r = angle of refraction

✓ **Specific refraction:** The specific refraction r of a substance is equal to the substance's molecular refraction **R** divided by its molecular weight **M**.

→ The refractive index of a liquid varies with temperature and pressure but specific refraction independent of these variables.

$$r = \frac{1}{\rho}\frac{n^2 - 1}{n^2 + 2}$$

✓ **Molar refraction:** Molar refractivity is a measure of the **total polarizibility** of a mole of a substance and is dependent on the temperature, the index of refraction, and the pressure.

$$A = \frac{M}{\rho}\frac{n^2 - 1}{n^2 + 2} \approx \frac{M}{\rho}\frac{n^2 - 1}{3}.$$

Abbe Refractometer

→ Instrument used for determination of RI of a liquid is known as **Abbe refractometer**.

→ In the Abbe refractometer the liquid sample is sandwiched into a thin layer between an **illuminating prism** and a **refracting prism**. The refracting prism is made of a glass with a **high refractive index** and the refractometer is designed to be used with samples having a refractive index smaller than that of the refracting prism.

→ A **light source** is projected through the illuminating prism, the bottom surface of which is ground (i.e., roughened like a ground-glass joint), so each point on this surface can be thought of as generating light rays traveling in all directions. A detector placed on the back side of the refracting prism would show a **light** and a **dark region**.

Short Questions/Blanks

1. What is symbol for viscosity? -η

2. The reciprocal of viscosity is called Fluidity.

3. Which law related to Refractive index? – Snell's law

4. Water Specific gravity? – 1

5. Abbe refracrometer used for -RI determination.

Optical activity

→ Optical activity is the ability of a **chiral molecule** to rotate the **plane of plane-polairsed light**, measured using a **polarimeter.**

→ **Dextrorotary** designated as d or (+), **clockwise rotation** (to the right)

→ **Levorotary** designated as l or (-), **anti-clockwise rotation** (to the left)

→ **Enantiomers** are stereoisomers which are **non superimposable**, **mirror images** isomer.

→ A mixture of equal amounts of two stereoisomers of an optically active substance is called a **racemic mixture or racemate.** It is **optically inactive**.

→ **Meso compounds** are **achiral** compounds that has multiple chiral centers. It is **superimposed** on its mirror image and is **optically inactive** despite its stereocenters.

→ **Specific rotation ([α])** is a property of a **chiral chemical compound**. It is defined as the change in orientation of monochromatic plane-polarized light, per unit distance–concentration product, as the light passes through a sample of a compound in solution.

Polarimeter

→ A polarimeter is a scientific instrument used to measure the **angle of rotation** caused by passing polarized light through an **optically active substance**.

→ Some chemical substances are **optically active**, and polarized (uni-directional) light will rotate either to the **left** (counter-clockwise) or **right** (clockwise) when passed through these substances.

→ The amount by which the light is rotated is known as the **angle of rotation**. The angle of rotation is basically known as observed angle. It value is depend on **concentration**, **tempetrature** and **wave length of light.**

→ The polarimeter is made up of two **Nicol prisms** (the polarizer and analyzer). The polarizer is fixed and the analyzer can be rotated. The prisms may be thought of as slits S_1 and S_2.

→ The light waves may be considered to correspond to waves in the string. The polarizer S_1 allows only those light waves which move in a **single plane**.

→ This causes the light to become plane polarized. When the analyzer is also placed in a similar position it allows the light waves coming from the polarizer to pass through it. When it is rotated through the **right angle** no waves can pass through the right angle and the field appears to be dark.

→ If now a glass tube containing an optically active solution is placed between the **polarizer** and **analyser** the light now rotates through the plane of polarization through a certain angle, the analyser will have to be rotated in same angle.

Dipole moment

→ A dipole moment arises in any system in which there is a separation of charge. They can, therefore, arise in ionic bonds as well as in covalent bonds. Dipole moments occur due to the difference in electronegativity between two chemically bonded atoms.

→ **Symbol:** **δ**(read **delta)**

→ **Unit:** Debye (D),

→ **1D** = 3.33564 × 10^{-30} C.m,

where **C** is **Coulomb** and **m** denotes a **meter**.

→ The bond dipole moment is a vector quantity since it has both magnitude and direction.

→ A bond dipole moment is a measure of the polarity of a chemical bond between two atoms in a molecule.

→ The bond dipole moment (μ) is also a vector quantity, whose direction is parallel to the bond axis. In chemistry, the arrows that are drawn in order to represent dipole moments begin at the positive charge and end at the negative charge.

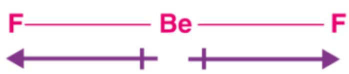
→ **Formula of dipole moments**

→ Dipole Moment (**μ**) = Charge (**Q**) * distance of separation (**d**)

❖ **Examples of dipole moments**

✓ **Dipole moment of BeF_2**

→ In a beryllium fluoride molecule, the bond angle between the two beryllium-fluorine bonds is 180°. Fluorine, being the more electronegative atom, shifts the electron density towards itself. The individual bond dipole moments in a BeF_2 molecule are illustrated below.

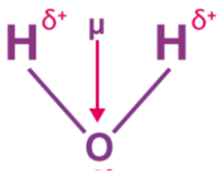


Bond dipole in BeF_2

- → Bond dipole moment (μ) is also a vector quantity, whose direction is parallel to the bond axis. In chemistry, the arrows that are drawn in order to represent dipole moments begin at the positive charge and end at the negative charge.
- → From the illustration provided above, it can be understood that the two individual bond dipole moments cancel each other out in a BeF_2 molecule because they are equal in magnitude but are opposite in direction. Therefore, the net dipole moment of a BeF_2 molecule is zero.

✓ **Dipole moment of H_2O**

- → In a water molecule, the electrons are localized around the oxygen atom since it is much more electronegative than the hydrogen atom. However, the presence of a lone pair of electrons in the oxygen atom causes the water molecule to have a bent shape (as per the VSEPR theory). Therefore, the individual bond dipole moments do not cancel each other out as is the case in the BeF_2 molecule. An illustration describing the dipole moment in a water molecule is provided below.



1. What is the symbol of dipole moment? –μ
2. What is the symbol of specific angle of rotation? – [α]
3. Which instrument used for optically active substances?- Polarimeter
4. Sucrose is optically Inactive

Learning Outcome

- → Lern physical properties such as parachor and molar volume useful to determine molecular structure of compounds.
- → With help of dipole moment find out the molecule polar or non-polar.
- → With help of viscosity concept used in determine fluidity of liquid on surface.