# ⇒ LIQUIDS

- **{Additive Propeeties}:** (individual atoms are involved)
  - Never changed ie. Mass of atom, weight, Molecular heat, Radioactivity.

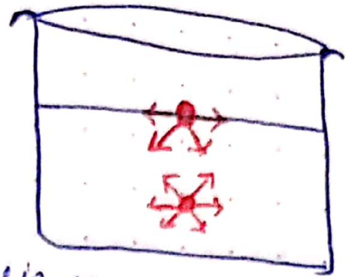
- **{CONSTITUTIVE PROPERTIES}:**
  - → Depends upon arrangement of atoms in a molecule.
  - → Do not depend upon their number.
  - → i.e V.P, Viscosity, Surface Tension, D.M, refractive index, optical activity.

- **{Additive and Constitutive Properties}:**
  - These are additive but can be modified by arrangements change. ie Parachor, rheochor, polarization etc

- **{Colligative Properties}:** Depends upon no of Particles.
  - independent of nature & Structure

(i) Lowering of V.P (ii) Elevation of B.P (iii) Depression of F.P (iv) Osmosis

# ⇒ Surface Tension:



- Molecule at center {net F=0}
- Molecules at surface experience net inward attraction. Surface behave as in Tension

"Force in N acting along liquid surface at 90°C to line 1 m in length"

{ $N m^{-1}$ | $dynes\ cm^{-1}$ | $J m^{-2}$ }

## ⇒ Effect of Temp:

$$\gamma \left[\frac{M}{D}\right]^{2/3} = K\left[T_c - T\right]$$

$T = T_c \Rightarrow \gamma = 0$

T = temp  $T_c$ = critical temp

- Surface tension decrease as temp increase

Surface tension ∝ D

Molten metals also have surface tension

## ⇒ Capillary Action:

[depends upon Radius & Surface tension of liquid]

"Adhesive forces are greater than cohesive forces"

## ⇒ Interfacial Tension:

Surface tension acting along the surface of separation b/w two immiscible liquids.

## ⇒ Surface Active Agents:

Substances that lowers the surface tension of water i.e. soap, ethyl Alcohol etc.

- Soap lowers the interfacial tension b/w water & grease.

## ⇒ MEASUREMENT OF SURFACE TENSION:-

(i) Capillary rise method (ii) Torsion method
(iii) The drop method $\left[\frac{\gamma_1}{\gamma_2} = \frac{m_1}{m_2}\right]$

## ⇒ THE PARACHOR

$$[P] = \frac{M \gamma^{1/4}}{D}$$

Parachor is the product of surface tension and molar volume of liquid.

$$[P] = \left[\frac{M}{D}\right] \cdot \gamma^{1/4} \qquad \left[\frac{M}{D}\right] = V_m \text{ (molar volume of liq)}$$

$$= \left(\frac{cm^3}{mol}\right)\left(\frac{erg}{cm^2}\right)^{1/4}$$

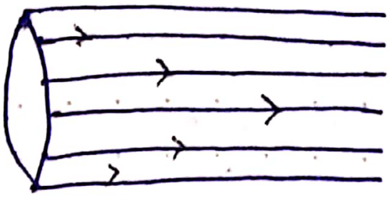
vapours of liquid is 1600 times greater than liquid

Parachor is additive constitutive property

- It is used to verify structure of compounds

- Parachor value of  is 206.9

## VISCOSITY:



- Property which oppose the flow.
- Resistance b/w the two layers.

$$\eta = -\left[\frac{F}{A}\right] \times \frac{1}{\frac{dv}{dx}}$$

↓

Units: $\eta = \frac{N}{m^2} \times \frac{1}{\frac{velocity}{distance}} \Rightarrow = \frac{N}{m^2} \times \frac{Velocity}{distance}$

$$= \frac{kg\, m\, s^{-2}}{m^2} \times \frac{m}{m/s}$$

$$\boxed{= kg\, m^{-1} s^{-1}}$$

1 Poise = 0.1 $kg\, m^{-1} s^{-1}$

## Fluidity:

$\phi = \frac{1}{\eta}$ $(Poise)^{-1}$

Reciprocal of viscosity.

## MEASUREMENT OF VISCOSITY:-

- Ostwald's viscometer is used
- Relative viscosity with $H_2O$.

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

t = time ; d = density
$\eta$ = viscosity.

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$\eta$ = coefficient of viscosity.

1 poise = $10^{-1}$ $kg\, m^{-1} s^{-1}$

- $\eta \propto$ Inter molecular forces.
- $\eta \propto \frac{1}{Size}$
- $\eta \propto \frac{1}{Temp}$
- $\eta \propto$ density.
- $\eta \propto \frac{1}{P}$

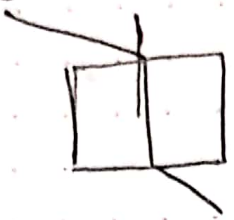
2% velocity decrease by 1°C temp rise

- Viscocity of n-Alkanes is higher than branched
- Trans isomers viscosity is greater than cis
- Rheochor

$[R] = \frac{M}{d} \eta^{1/8}$

- Use to measure molar masses of polymers.

## ⇒ REFRACTIVE INDEX :-



- Lighter medium to dense medium, moves towards the normal. and vice versa.

**Snell's Law:** $n = \frac{\sin \hat{i}}{\sin \hat{r}}$

**Critical Angle:** incident angle increase, refraction angle also increase. ($90^\circ \rightarrow$ max value)

critical angle is obtained by putting incident angle $90^\circ$

(To Find R. Index)

- Abbe's Refractometer
- Pulfrich Refractometer
- Sodium D Line light is used. ($n_D$)

## ⇒ REFRACTIVITY :-

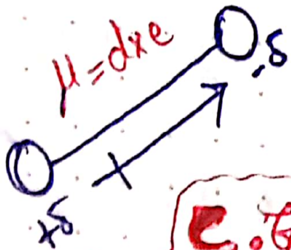
- R. Index of liquids changes with change in wavelength of light & Temperature.
- To eliminate temp effect. Lorentz & Lorenz Eq is used.

$$R = \frac{n^2 - 1}{n^2 + 1} \times \frac{1}{d} \Rightarrow \text{Units} = Kg^{-1} m^3 \text{ or } g^{-1} cm^{+3}$$

(molar refraction) $$R_m = \frac{n^2 - 1}{n^2 + 1} \times \frac{M}{d} \Rightarrow \text{Units} = m^3 mol^{-1} \text{ or } cm^3 mol^{-1}$$

(additive Property)

# DIPOLE MOMENT:




- Product of electric charge and distance b/w charges
- Vector Quantity.
- Quantitative measurement of Polarity
- D.M = 0 for homonuclear diatomic molecules.
- D.M ∝ electronegativity diff

## Induced D.M:

- Depends upon strength of $\bar{e}$ field.
- Independent of Temp.

**C.G.S**

$d = \mathring{A} = 10^{-8}\,cm$

$e = 4.8 \times 10^{-10}\,e.s.u$ (electrostatic Unit)

$\mu = cm \times e.s.u$

$= 10^{-8}\,cm \times 4.8 \times 10^{-10}\,e.s.u$

$\mu = 4.8 \times 10^{-18}\,cm\,esu.$

$10^{-18}\,cm\,esu = D$

$\mu = 4.8\,D$ (Debye)

**S.I**

$d = 1\mathring{A} = 10^{-10}\,m$

$e = 1.602 \times 10^{-19}\,C$

$\mu = 10^{-10}\,m \times (1.602 \times 10^{-19}\,C)$

$\mu = 16.02 \times 10^{-30}\,mC$

$4.8\,D = 16.02 \times 10^{-30}\,mC$

$1D = 3.38 \times 10^{-30}\,mC$

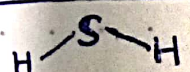
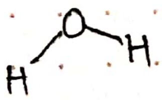
## MEASUREMENT:

(i) Vapour Temp method (ii) Refraction method.

## Applications:

(i) Comparison of polarities
(ii) % ionic character.
(iii) Shape of molecule [O=C=O linear D.M = 0)
(iv) Comparison of cis - Trans [E → DM ≠ 0] [Z DM = 0]
(v) Comparison of o, m & p - isomers

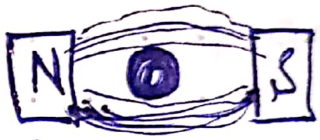
o, m → $\mu \neq 0$ ; p → $\mu = 0$

| | | | | |
|---|---|---|---|---|
|  $\mu = 1.61\,D$ |  $\mu = 0.95\,D$ | HF → 43% ionic 57% ionic |  $\mu = 1.85\,D$ | C≡O $\mu = 0.12\,D$ |

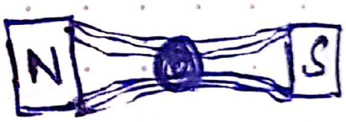
# ⇒ MAGNETIC PROPERTIES:

- Magnetic Permeability: Tendency of magnetic lines to pass through medium as compare to vaccum.
  - $\alpha = 1$ for vaccum.
  - $\alpha < 1$ for diamagnetic.
  - $\alpha > 1$ for Paramagnetic

- Diamagnetic Substance:-
  - $\alpha < 1$ prefer to pass through vaccum




- Paramagnetic Substance:-
  - $\alpha > 1$ prefer to pass through medium/substance.



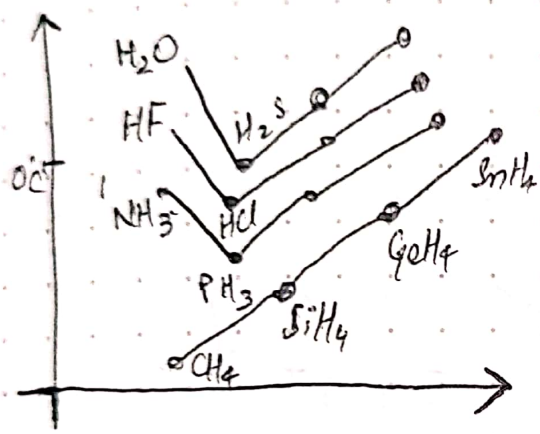

- Ferromagnetic Substance:-

These are paramagnetic but value of $\alpha$ is very high i.e. $10^3$.

# HYDROGEN BONDING:

- F, O, N
- HF is zig-zag due to H-bonding.
- HF is weaker than HCl due to H-bonding.

→ THERMAL PROPERTIES OF COVALENT HALIDES.




## STRUCTURE OF ICE

→ water is in tetrahedral structure.
→ Liquid water → no regular arrangement.
→ Ice → more regular and arranged
→ Empty spaces.
→ Ice occupy 9% more space.
→ Density decrease. [1g/cm³ at 4°C and 0.98 g/cm³ at 0°C]

→ CLEANSING ACTION OF SOAP: Polar dissolve → H.B

- Strength of H-bonding is 20 times less than covalent Bond

- $H_2O$ Liquid & $H_2S$ is gas.

- HF → one H-bond
  $H_2O$ → Two H-bonds

- $NH_3$ form one H-bond.

- Small size molecules of Organic comp easily dissolve having -OH group.

## ⇒ H-Bonding in Biological compounds & Food:

- → Amino Acids → coiled → helix Structure.
- → Helix → Right Handed / → Left Handed.
- → >NH & >C=O
- → 27 Amino Acids units for each turn of Helix.

- DNA

- 18–20 Å
- Linked together by H-bonding.

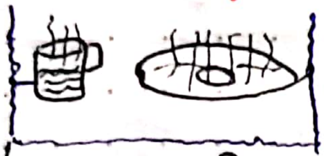
## → Hydrogen Bonding in Paints, Dyes, Textile etc.

- H-bonding in thread making
- Rigidity & tensile strength.

→ (Endothermic)

# → EVAPORATION: (Liq → vap) (Spontaneously)

- Molecules of liquid are not motionless.
- Energies are not equally distributed.
- Continues at all temp.
- → E ∝ Surface Area → • E ∝ Temp → • E ∝ $\frac{1}{\text{intermolecular forces}}$

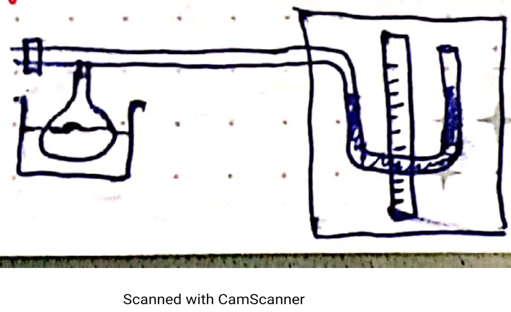


# → VAPOUR PRESSURE:

- → • Close system. • Given temp
- → • Pressure exerted by the vapour with (liquid or solid) in equilibrium.
- → • Clausius - Clapeyron relation is used to discuss non-Linear increase of V.P with temp
- → • Independent of amount & Surface Area.
- → • $Kg\,m\,s^{-2}$ or $N\,m^{-2}$ (Pascal)
- → • Very low vapour pressure of solids can be measured by using KUNDSEN EFFUSION CELL
- → • Vapour Pressure depends upon
  (i) Size (ii) FORCE (iii) Temp (iv) V.P ∝ $\frac{1}{\text{Force}}$
- → • Glycerol has Lowest V. pressure.

# → MANOMETRIC METHOD:

- Freezing → To remove air




$P = P_a + \Delta h$

# → BOILING POINT:

- V.P ≈ External Pressure.
- K.E ∝ T
- At certain temp, K.E become maximum, and further heating will not change K.E..
- This Heat will break the intermolecular forces and Liq → vapours.
- Molar heat of vaporization for water is 40.6 kJ/mol.

**imp B.P at 1atm**

| | |
|---|---|
| • Benzene | 80.15°C |
| • $CCl_4$ | 76.50°C |
| • Phenol | 181.80 |
| • Water | 100.00 |
| • $CS_2$ | 46.30 |

V.P of $H_2O$ at 0°C is 4.8 torr and $C_2H_5$–O–$C_2H_5$ is 200 torr

- A liquid can boil at any temp by changing Pressure.

- At p=1489 torr B.P of water is 120°C and 25°C at 23.7 torr.

- B.P ∝ External P

- Mount Everest: P= 323 torr ; B.P=69°C
- Murree hills. P= 700 torr, B.P=98°C
- Pressure Cooker

- Vaccum distillation → Rotary evaporator ↔ Economical less fuel.

- Glycerin Boils and also decompose at 290°C at 1atm. at 50 torr pressure, B.P of Glycerine is 210.

Physical Change → Energy change → Quantitative measurement of intermolecular forces

Enthalpy Change → cons Pressure. (ΔH)

# Enthalpy of

ΔH in kJ/mol.

| | |
|---|---|
| → Reaction (±) | $2H_2 + O_2 \rightarrow 2H_2O$ ($\Delta H = -285.8$) |
| → Formation (±) | $Mg + \frac{1}{2}O_2 \rightarrow MgO$ ($\Delta H = -692$) \| $C + O_2 \rightarrow CO_2$ ($\Delta H = -393.7$) |
| → Neutralization (−) | $HCl + NaOH \rightarrow NaCl + H_2O$ ($\Delta H = -57.4$) |
| → Automization (+) | $\frac{1}{2}H_2 \rightarrow H$ ($\Delta H = 218$) |
| → COMBUSTION (−) | $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ ($\Delta H = -1368$) |
| → Solution (±) | $NH_4Cl \rightarrow (+16.2)$ \| $Na_2CO_3 \rightarrow (-25)$ |

$\Delta H_{vap} > \Delta H_{fusion}$

- Liq attractive forces

$\Delta H_{sub} > \Delta H_{vap}$

- Solid attractive forces

$\Delta H_v$

→ $H_2O > NH_3 > HCl$ [$SO_2$]

40.6 21.7 15.6 24.3

→ $F_2 < Cl_2 < Br_2 < I_2$ (Strongest London force among)

5.9 10.0 15.0 22.0

→ $CH_4 < C_2H_6 < C_3H_8 < C_6H_{14}$

8.6 15.1 16.9 30.1

## → LIQUID CRYSTALS :

- 1888 → Frederick Reinitzer → Austrian botanist
- Cholesteryl Benzoate → Milky Liquid → Clear Liquid
  - Melting T: 145°C; Clearing T: 178°C
  - Reverse Process (Clear Liquid → Milky Liquid)
- Turbid liquid Phase called Liquid crystal
- Liquid Crystals have definite shape (Solid property) as well as surface Tension, viscosity etc (Liquid Properties).
- Mostly Optical Properties
- Solid crystals can be isotropic or anisotropic but liquid crystals are always anisotropic
- Nematic
- Smectic
- Cholesteric

- They have FLUIDITY of liquids and optical properties of crystal.

## → USES:

- In temp Sensors
- Potential Failure in electric circuits.
- Locate veins, arteries, tumor etc (Blue colour) (Skin Thermography)
- LCD's
- Solvent in chromatography
- Oscillograph