PHASES OF MATTER -2 PROPERTIES DUE TO INTERMOLECULAR FORCES

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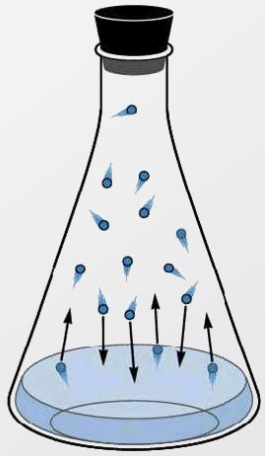
PROPERTIES OF INTERMOLECULAR FORCES

The type of intermolecular forces will determine:

- Vapor Pressure
- Boiling point
- Freezing point
- Surface tension
- Viscosity
- Adhesion and cohesion
- Solubility of substances

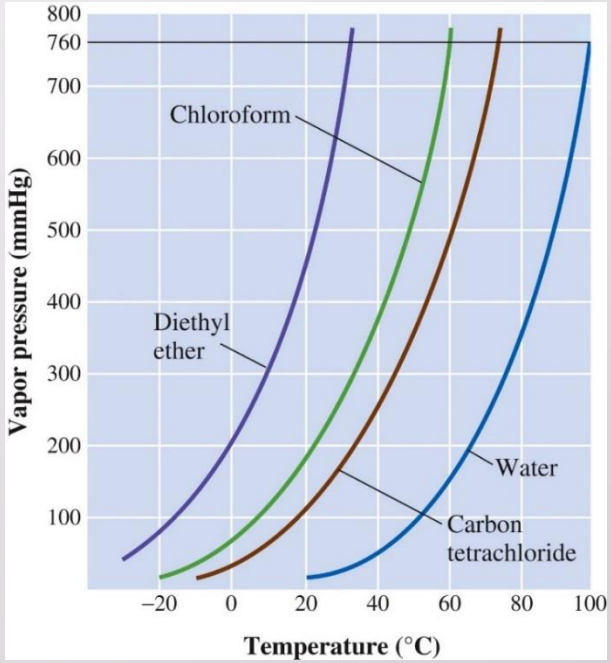
VAPOR PRESSURE



- The **vapor pressure** of a liquid is the partial pressure of the vapor **over** the liquid at a particular temperature.
- When a liquid is placed in a closed vessel, the partial pressure of its vapor increases over time until it reaches equilibrium. At equilibrium, evaporation and condensation continue to occur at the same rate called dynamic equilibrium.

<u>Vapor pressure depends on IM forces and temperature</u>

- If the IM forces are more then molecules will tend to stick together and not vaporize hence VP will be less.
- If the temperature is increased, the kinetic energy of molecules increases and they will break free of the IM forces and increase the VP.



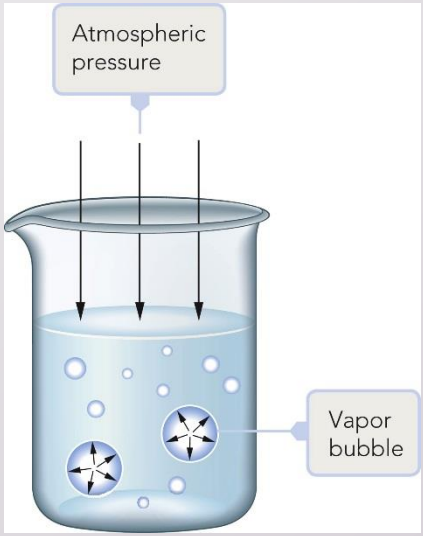
BOILING POINT

- Boiling point is the temperature at which the vapor pressure is equal to the atmospheric pressure (external pressure).
- At this temperature bubbles form within the liquid – looks like boiling.
- As the pressure on the liquid increases the boiling point increases – e.g. in a pressure cooker. Boiling point at a higher altitude will be lower than normal atmospheric pressure.
- Heat of vaporization – heat required to vaporize a liquid.

e.g. $H_2O(l) \rightarrow H_2O(g)$; $\Delta H_{vap} = 40.7$ kJ/mol

- If the IM forces are high then bpt. will also be higher.

e.g. $H_2O > H_2S$

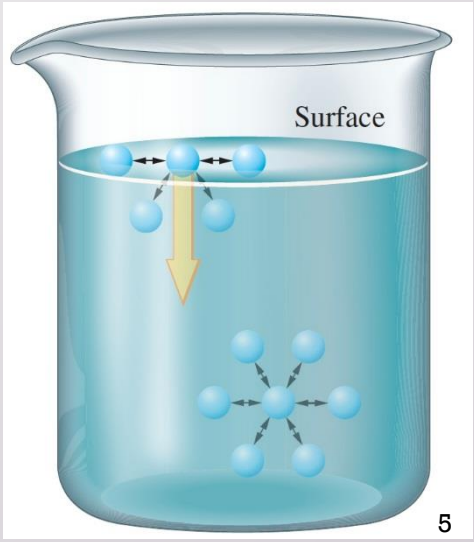


SURFACE TENSION

- Surface tension is a quantitative measure of the elastic force on the surface of a liquid.
- Surface tension occurs because the molecules at the surface of a liquid experience a net force toward the center of the liquid.
- The stronger the intermolecular forces the higher the surface tension.
- Energy of molecules on the surface is more so they want to vaporize, but if IM forces are more they will be pulled inside – thus creating a thin film of tension.

e.g. H_2O (water) > C_6H_{12} (hexane)

- To break the surface tension one will need to reduce the IM forces.

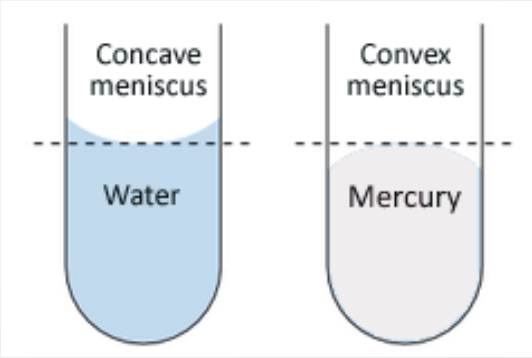


CAPILLARY ACTION: COHESION AND ADHESION

- Formation of a **meniscus** is a result of surface tension.
- Capillary action which results from a combination of
  - **Cohesion**: attractions between like molecules, cohesive forces
  - **Adhesion**: attractions between unlike molecules, adhesive forces

Water and glass

Adhesion > cohesion



Mercury and glass

cohesion > adhesion

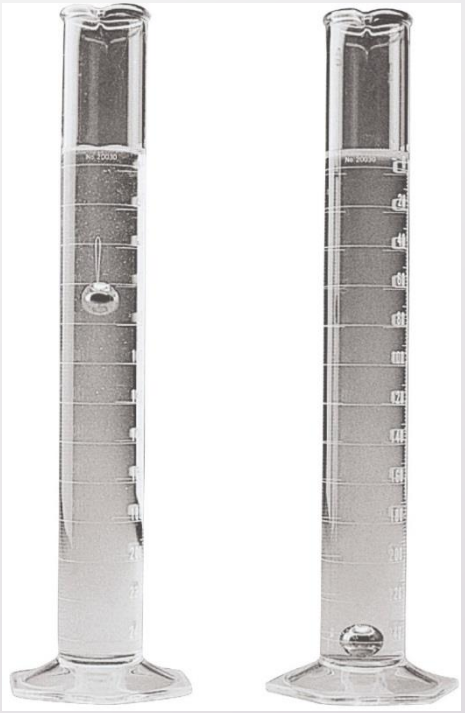
- Car waxing is cohesion, whereas pulling up blood in a capillary is adhesion.
- Similar IM forces lead to adhesion; dissimilar IM forces lead to cohesion.

VISCOSITY

- Resistance to flow exhibited by liquids and gases; e.g. the difference in the flow of syrup vs water.

- In the figure, steel balls were dropped into the glycerol and the water at the same time. Glycerol has higher viscosity (1.49 N s/m^2) so ball will drop slower than in water (1.01 x 10^{-3} N s/m^2).

- Higher IM forces causes higher viscosity.



glycerol **water**

PHYSICAL PROPERTIES - COMPARISON

Properties of some liquids.

Table 11.2 Properties of Some Liquids at 20°C

Substance	Molecular Weight (amu)	Vapor Pressure (mmHg)	Surface Tension (J/m^2)	Viscosity (kg/m·s)
Water, H_2O	18	1.8×10^{1}	7.3×10^{-2}	1.0×10^{-3}
Carbon dioxide, CO_2	44	4.3×10^{4}	1.2×10^{-3}	7.1×10^{-5}
Pentane, C_5H_{12}	72	4.4×10^{2}	1.6×10^{-2}	2.4×10^{-4}
Glycerol, $C_3H_8O_3$	92	1.6×10^{-4}	6.3×10^{-2}	1.5×10^{0}
Chloroform, $CHCl_3$	119	1.7×10^{2}	2.7×10^{-2}	5.8×10^{-4}
Carbon tetrachloride, CCl_4	154	8.7×10^{1}	2.7×10^{-2}	9.7×10^{-4}
Bromoform, $CHBr_3$	253	3.9×10^{0}	4.2×10^{-2}	2.0×10^{-3}

SOLUBILITY

- "Like dissolves like"
- Substances with the same IM forces will dissolve in each other.
- IM interactions are between solvent and solute molecules.
- The non polar substances will dissolve primarily in non polar substances – not in substances with dipole-dipole or H-bonding forces.
- Substances with dipole-dipole, H-bonding and ion-dipole IM forces should be soluble in each other.
- E.g. H_2O will dissolve CH_3OH, NaCl, sugar through different IM forces. It will not dissolve hexane C_6H_6 since the IM forces don't match up.
- Hexane, C_6H_6, should dissolve CH_3OCH_3 (ether) easily. However, the ether will be slightly soluble in H_2O due dipole-dipole interactions.

KEY CONCEPTS

- Vapor Pressure
- Boiling point
- Surface tension
- Viscosity
- Adhesion and cohesion
- Solubility of substances