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2. Fluids

1. General Characteristics

2. Dispersions
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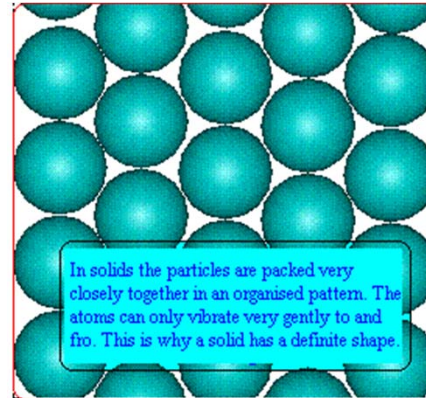
2.1. General Characteristics

1. **The Three States of Matter**
2. Mass, Moles and Density

2.1.1. Liquids and Gases

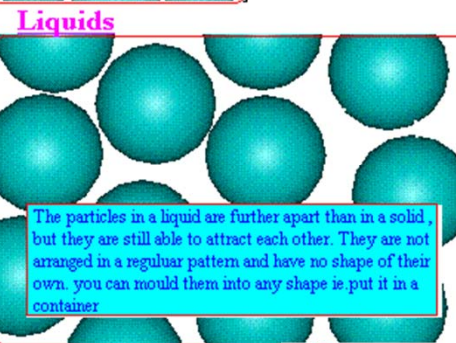
- Three States of Matter

- Solid
- Liquid
- Gaseous



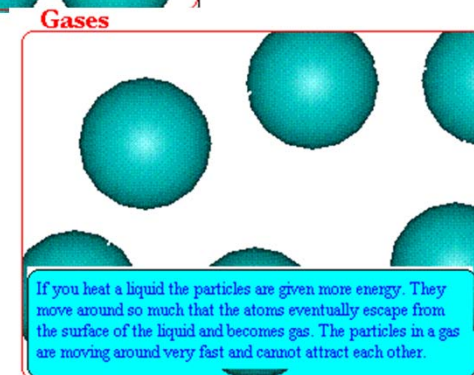
- Differences

- Reaction to external forces
 - Stability of external shape
- Strength of intermolecular forces
- Internal Energy



- Fluids

- Liquids
- Gases

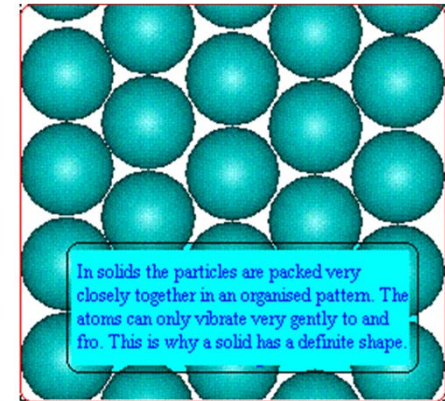


2.1.1. Liquids and Gases

- Three States of Matter

- **Solid**

- Relatively fixed molecular structure
- Strong cohesive forces between molecules over long distances
- Reaction to external forces: restoring of external shape
- Lowest internal energy
- Crystalline state: atoms arranged periodically (silicon, metals, ...)
- Non-crystalline state: atoms not organized within regular lattice (glass, plastics, ...)
- Quasi-crystalline: patterns not repeating at regular intervals (alloys)



- Liquid

- Gaseous

2.1.1. Liquids and Gases

- Three States of Matter

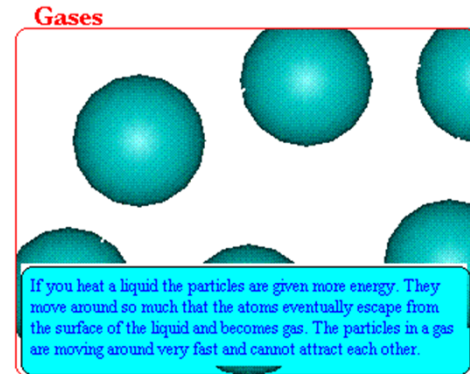
- Solid

- Liquid

- **Gaseous**

- No defined shape
- Occupying whole volume
- Reaction to pressure gradient → transport of particles
- Steady state: equal pressure within whole volume

- Forces between molecules very low or negligible (e.g. ideal gas)
- Random motion and occasional collisions with other molecules



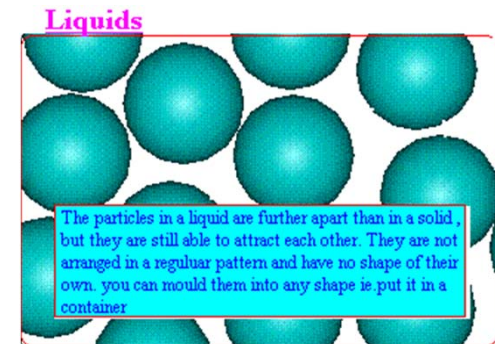
2.1.1. Liquids and Gases

- Three States of Matter

- Solid

- **Liquid**

- Intermediate state compared to solid and gas
 - Cohesive forces between molecules compared to solids
 - Molecular alignment on molecular length scales
 - No temporally fixed molecular positions
 - Higher kinetic energy compared to solids
 - Reaction to pressure gradient
 - (Convective) transport of particles
 - Shape defined by the minimum of potential energy
 - Surface tension
 - Interfacial forces with solids and gases
 - Spherical surface in absence of gravity
 - Gaseous



2.1. General Characteristics

1. The Three States of Matter
- 2. Mass, Moles and Density**

2.1.2. Mass, Moles and Density

- Mass m of body

$$m = NM$$

- Number of molecules N
- Molecular mass M

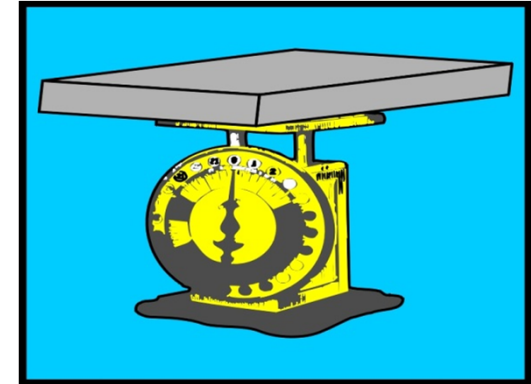
- Total number N of molecules in given sample

$$N = N_A n$$
$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

- Avogadro's constant N_A
- Number of moles n

- Particle density

$$\rho_N = \frac{N}{V}$$



2.1.2. Densities

- Volume per mole

$$V_n = \frac{V}{n} \simeq 22.41 \text{ mol}^{-1} \quad (\text{for gases})$$

- (Mass) density

$$\rho = \frac{m}{V}$$

Molar mass

$$M_n = \frac{m}{n}$$

substance	density $\rho/\text{g cm}^{-3}$
silica glass	2.66
lead	11.35
ethanol	0.7892
water	0.9982
mercury	13.5459
carbon dioxide	1.9769×10^{-3}
air	1.2929×10^{-3}
hydrogen	0.0899×10^{-3}

Table 2.1. Densities of selected solids and liquids at 20°C and gases at 0°C