Wetting - Thermodynamic conditions

- The phenomenon of wetting is very common in nature. Many processes depend on it, both in living and in inanimate nature. Suffice it to recall that from wetting depends the delivery of water to the leaves of various plants, the regulation of moisture evaporation by leaves, the delivery of moisture and nutrients to the roots of plants, the movement of fluid in the capillaries of the soil, the movement of fluid in the cells of living organisms.

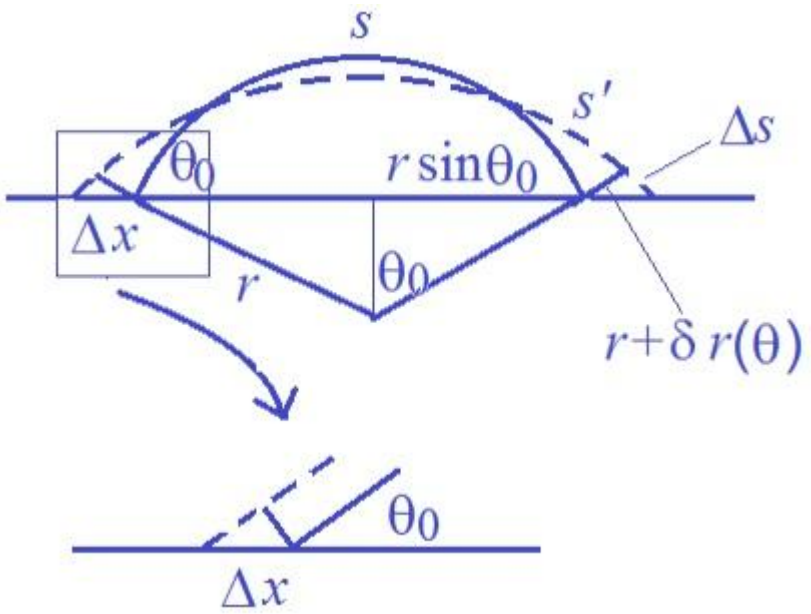
- Wetting is an intermolecular interaction of the condensed phases of a liquid and a solid or two immiscible liquids.

- Spreading of a liquid is a kinetic process of establishing the hydrodynamic equilibrium of a liquid on the surface of a solid body, which, as a rule, coincides with the establishment of thermodynamic equilibrium.

- Wetting is associated with intermolecular interactions, in which all forces can appear: dispersion, electrostatic, covalent, hydrogen and metal bonds.

- Consider a drop on a flat substrate. We assume that it has the shape of a spherical segment and forms an equilibrium angle θ_0 in equilibrium. We introduce the system from equilibrium by increasing the radius of the contact spot by Δx. Let us determine the change in the free energy

$$\Delta \mathcal{F} = 2\pi r \sin\theta \Delta x(\sigma_{sl} - \sigma_{sv}) + 2\pi r \sin\theta \Delta x \cos\theta \sigma_{lv} = 0. \quad (1)$$



- We put ΔF equal to zero, since in equilibrium F has a minimum value. Hence we get the equilibrium value of the edge angle θ_0 :

$$\cos\theta_0 = \frac{\sigma_{sv} - \sigma_{sl}}{\sigma_{lv}}.$$

or

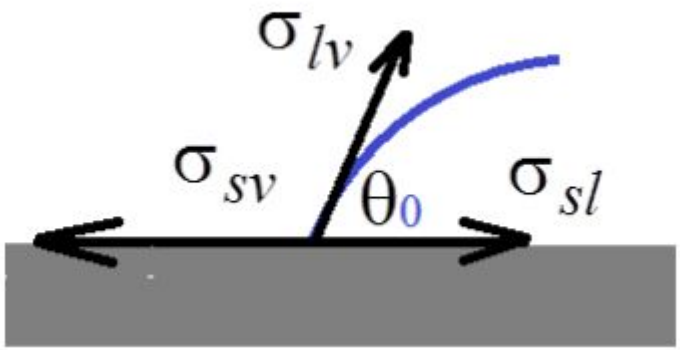
$$\sigma_{sv} = \sigma_{sl} + \sigma_{lv}\cos\theta_0.$$

Young's equation

Thermodynamic wetting conditions

- It follows from Young's formula if:

- $\sigma_{sv} > \sigma_{sl}$, то $\cos\theta_0 > 0$ и краевой угол – острый,
- $\sigma_{sv} < \sigma_{sl}$, то $\cos\theta_0 < 0$ и краевой угол – тупой.



- $\theta_0 < 90^0$ the angle edge and the liquid wet the surface; (Non-wetting)
- $\theta_0 > 90^0$ the angle is obtuse and the liquid does not wet the surface (Limited wetting)
- θ_0 -90^0 The angle is not established and the liquid spreads over the surface (Complete wetting (spreading))