15. WETTING AND SPREADING

$$\gamma_{sg} = \gamma_{s\ell} + \gamma_{\ell g} \cos\theta$$

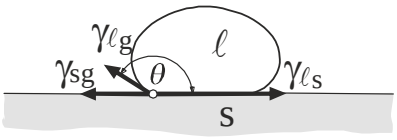
$$W_c = 2\,\gamma_{\ell g} \qquad W_a = \gamma_{\ell g} + \gamma_{sg} - \gamma_{\ell s} = \gamma_{\ell g}\,(1+\cos\theta)$$

$$S_{\ell/s} = W_a - W_c = \gamma_{sg} - \gamma_{\ell g} - \gamma_{\ell s}$$

Problem 15-01 Young equation, wetting angle

A small amount of liquid of density 0.779 g cm^{-3} and surface tension 28.4 mN m^{-1}, placed on the surface of plane alumina plate forms a sessile drop with a contact angle $\theta = 115^{o}$.
(a) Sketch the shape of the drop with the interfacial tensions and contact angle
(b) The interfacial tension between the liquid and the solid surface is 38 mN m^{-1}. Calculate the surface energy of the solid surface.

[(a)



(b) γ_{sg} = 26 mN m^{-1}]

Problem 15-02 Spreading coefficient, cohesion work

A drop of liquid placed on the plane surface of paraffin exhibits the contact angle 128º. The surface tension of the liquid is 28.5 mN m^{-1}. Calculate the cohesion work and Harkins spreading coefficient.

[W_c = 43 mJ m^{-2}, $S_{\ell/s}$ = 47.5 mJ m^{-2}]

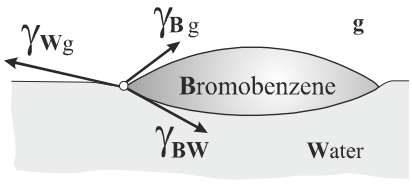
Problem 15-03 Spreading of a liquid on solid surface

A small amount of liquid was placed on a plane surface of a solid, the surface energy of which was 48.5 mJ m^{-2}. How will it behave? Will it spread? The interfacial tension liquid-solid surface has the value of 18.3 mN m^{-1}. The surface tension of the liquid has been determined by the capillary rise method: in the vertical capillary of inner diameter 0.16 mm the elevation of the liquid of 5.7 cm was measured. The liquid density is 0.912 g cm^{-3} and the studied liquid completely wets the walls of the capillary.

[$\gamma_{sg} > \gamma_{s\ell} + \gamma_{\ell g}$; $S_{\ell/s}$ = 9.8 > 0, cos θ > 1 – liquid spreads ($\gamma_{\ell g}$ = 20.4 mN m^{-1})]

Problem 15-04 Spreading of a liquid on liquid surface

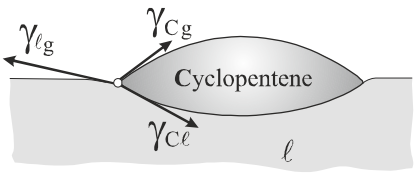
The surface tension of bromobenzene (B) at the temperature of 20 ºC is 35 mN m^{-1} and its density has the value of 1.495 g cm^{-3}, the surface tension and density of water (W) are 72.75 mN m^{-1} and 0.9982 g cm^{-3}, respectively. Interfacial tension between water and bromobenzene is 39 mN m^{-1}. Will a small amount of bromobenzene spread on the water surface or it will take the form of a lens?



[$S_{B/W} = \gamma_{Wg} - \gamma_{Bg} - \gamma_{BW}$ = –1.25 mN m^{-1} < 0 ⇒ bromobenzene does not spread]

Problem 15-05 Spreading of a liquid on liquid surface

Estimate what is the minimal value of the interfacial tension between cyclopentene (C) and another liquid (ℓ), immiscible with cyclopentene, at which the cyclopentene would still spread on this liquid surface. The surface tension of the liquid was measured by the capillary rise method: at the temperature of 20 °C the level of the studied liquid in the glass capillary of inner diameter of 0.8 mm climbed to the height of 2.5 cm above the horizontal level of the liquid in the wide beaker. The liquid density is 1.06 g cm^{-3} and it wets the material of the capillary completely. The density of cyclopentene is 0.762 g cm^{-3}, molar mass 68 g mol^{-1}, and its surface tension 21.6 mN m^{-1}.



[$\gamma_{C/\ell}$ < 30.4 mN m^{-1} ($\gamma_{\ell g}$ = 52 mN m^{-1})]