Contact Angle

Having identified the phenomenon of **surface tension** as resulting from the special arrangement of intermolecular forces near the surface of a liquid, we should move on to describe the more complex arrangement of intermolecular forces that occurs at the junction of the boundaries seperating a solid surface and two immiscible fluids. A common circumstance is that in which a gas/liquid interface meets a solid surface as sketched in Figure 1. Then the interplay of forces between the solid and liquid molecules (and with the gaseous or other fluid molecules if this is significant) leads to an equilibrium configuration of the gas/liquid surface in which the angle between the tangent to the gas/liquid surface and the tangent to the solid surface at the intersection point is fixed. This angle, which by convention is measured through the liquid, is known as the "contact angle".

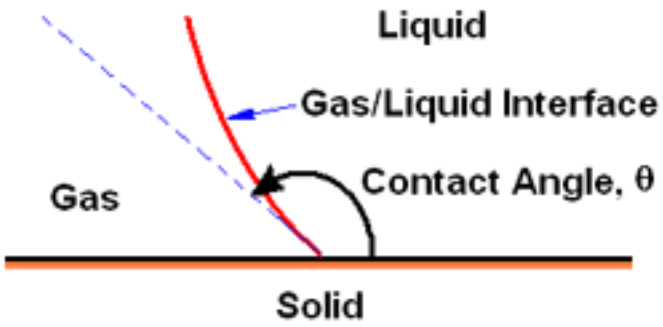

Figure 1: Sketch defining the contact angle, θ.

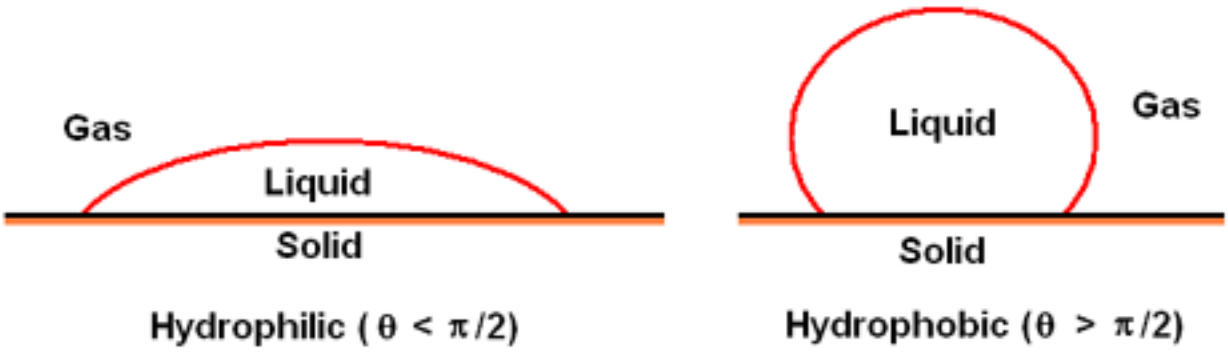

Figure 2: Hydrophilic (left) and hydrophobic (right) circumstances.

Some solid/liquid combinations such as water on a clean metal surface have a contact angle that is less than $\pi/2$ as sketched on the left in Figure 2. When this is the case the liquid will tend to spread out on the solid surface so this circumstance is termed "hydrophilic"; the liquid is said to "wet the surface". Other solid/liquid combinations such as water on teflon or mercury on glass have a contact angle that is greater than $\pi/2$ as sketched on the right in Figure 2. When this is the case the liquid will not tend to spread out on the solid surface but will remain in globules. This circumstance is termed "hydrophobic" and the surface is termed "non-wetting".

TABLE I. Values of the contact angle at various liquid/solid junctions.
(Values at normal temperatures.)
References: Carey (1992), Shaughnessy *et al.* (2005)

Liquid	Solid	Third phase	Contact Angle
Water	Teflon	Air	108°
Glycerol	Teflon	Air	100°
Carbon Tetrachloride	Teflon	Air	36°
Water	Typical metal surface	Air	$\approx 20^\circ$
Water	Copper	Air	86°
Ethanol	Copper	Air	$14 - 19^\circ$
Water	Clean glass	Air	$\approx 0^\circ$
Mercury	Clean glass	Air	$\approx 130^\circ$

Like the surface tension, the contact angle is very sensitive to contamination. This is an everyday experience, for example in observing that a slight film of grease on a solid surface can radically change its wetting properties. The grease molecules cause separation between the solid and liquid molecules thus altering the equilibrium configuration. Indeed, the sensitivity to contamination is so severe that is difficult to provide any useful data on contact angles; however, some data that can be used as a guideline is included in Table I.

The contact angle in combination with the surface tension, leads to several frequently observed phenomena, specifically the **liquid meniscus** (see Section (Cp)) and **capillarity** (see Section (Cq)).