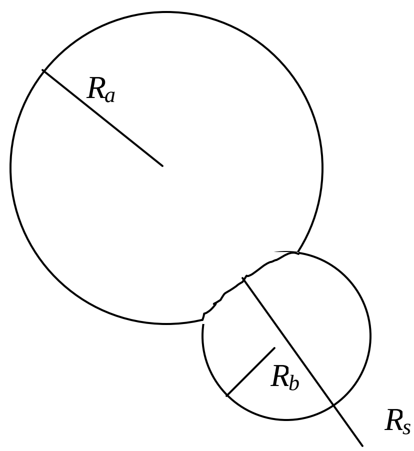
Chem. Engr. 06-607 Physical Chemistry of Colloids and Surfaces

Homework #2 **1-31-02**

Due: 2-12-02, beginning of class.

1. Two spherical bubbles come into contact and fuse in a liquid of hydrostatic pressure P. The radius of the larger bubble is R_a and that of the smaller bubble is R_b. There is a curved septum where the two bubbles are in contact. The radius of curvature of the septum is R_s. Derive an equation that relates R_s to R_a and R_b. (Note: the septum is a thin liquid film, so it has a vapor/liquid interface on *both* sides.) Why is the septum shaped the way it is?



2. Show that the Thompson equation for nucleation of vapor bubbles in a boiling liquid is:

$$\Delta H_{vap}\left[\frac{1}{T_0}-\frac{1}{T}\right]=R\ln\left[\frac{\frac{2g}{r}+P_l}{P_l}\right]$$

where P_l is the pressure in the bulk liquid phase, set by the ambient pressure of the surrounding gas. If the heat of vaporization is 31 kJ/mol at 272 C and the surface tension of water is 18.4 mN/m at 272 C, find the radius of a vapor bubble in equilibrium with liquid at an ambient pressure of 1 atm and T=272 C.

3. NaCl particles (density=2.17 g/cm^3) with a specific surface area of 4.25 x 10^5 cm^2/g show a supersaturation of 6.71% in ethanol (T=25 C). Assuming the crystals are uniform spheres, find their radius *(r)* and estimate the NaCl/ethanol interfacial tension *(g)* from this solubility data.

Hint: for 1:1 salts in liquids, the Kelvin equation is:

$$\frac{Mg}{rr} = RT \ln\left(\frac{S}{S_0}\right)$$

where M is the molecular weight of the salt, r is the density of the salt, S is the solubility of the spherical particle and S_0 is the solubility of a flat particle.

4. The surface tension of isoamyl alcohol (liquid "B") and its interfacial tension with water (liquid "A") at T = 25 C are listed below. g_B is the pure tension of pure B, while $g_{B(A)}$ represents the surface tension of A that is saturated with B, and g_{AB} represents the A/B interfacial tension. The surface tension of water at 25 C is 72.2 mN/m.

a) Will isoamyl alcohol spread on water?
b) Will water spread on isoamyl alcohol?
c) Will either of the situations considered in parts (a) or (b) produce the "strange" behavior where a liquid initially spreads on the other, only to retract into a lens after the passage of time?

g_B = 23.7 mN/m
$g_{B(A)}$ = 23.6 mN/m
$g_{A(B)}$ = 25.9 mN/m
g_{AB} = 5 mN/m

5. If g_L and q are measured for a homologous series of liquids on a given low-energy solid surface, a plot of *cos* q vs. g_L results in a straight line. Estimate the critical surface tension for a Teflon surface with the following wetting characteristics. Is this value a good estimate of the surface energy (tension) of the Teflon?

Compound	g_L **(mN/m)**	q **(deg)**	**Compound**	g_L **(mN/m)**	q **(deg)**
hexadecane	27.6	46	nonane	22.9	32
tetradecane	26.7	44	hexane	21.8	26
dodecane	25.4	42	heptane	20.3	21
undecane	24.7	39	octane	18.4	12
decane	23.9	35	pentane	16.0	spreads