

Problem 2.77

[Difficulty: 2]

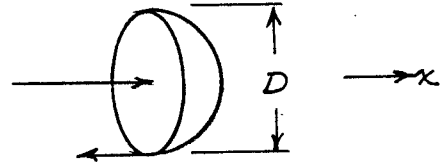
2.77 Small gas bubbles form in soda when a bottle or can is opened. The average bubble diameter is about 0.1 mm. Estimate the pressure difference between the inside and outside of such a bubble.

Solution: Consider a free-body diagram of half a bubble:

Two forces act:

Pressure: $F_p = \Delta p \frac{\pi D^2}{4}$

Surface tension: $F_s = \sigma \pi D$



Summing forces for equilibrium

$$\sum F_x = F_p - F_s = \Delta p \frac{\pi D^2}{4} - \sigma \pi D = 0$$

$$\text{so } \frac{\Delta p D}{4} - \sigma = 0 \quad \text{or } \Delta p = \frac{4\sigma}{D}$$

Assuming soda-gas interface is similar to water-air, then $\sigma = 72.8 \text{ mN/m}$, and

$$\Delta p = 4 \times 72.8 \times 10^{-3} \frac{\text{N}}{\text{m}} \times \frac{1}{0.1 \times 10^{-3} \text{ m}} = 2.91 \times 10^3 \frac{\text{N}}{\text{m}^2} = 2.91 \text{ kPa}$$

Δp