81.

Problem 17.57 (RHK)

A soap bubble in air has a radius of 3.20 cm. *It is then blown up to a radius of* 5.80 cm. *We can use* 26.0 mN/m (constant) *for the surface tension of the bubble.* (a) *We have to find the initial pressure difference across the bubble film.* (b) *Pressure difference across the film at the larger size.* (c) *Work done on the atmosphere in blowing up the bubble.* (d) *Work done in stretching the bubble surface.*

Solution:

Gauge pressure inside a bubble of radius r is

$$\Delta p = \frac{4\gamma}{r}.$$

(a)

As the radius of the bubble film initially is 3.20 cm,

$$(\Delta p)_{in} = \frac{4\times 26.0\times 10^{-3}}{3.20\times 10^{-2}}\,\text{Pa} = 3.25\text{ Pa}.$$

(b)

As the radius of the bubble film finally is 5.80 cm,

$$\left(\Delta p\right)_{fin} = \frac{4\times 26.0\times 10^{-3}}{5.80\times 10^{-2}} \text{ Pa} = 1.79 \text{ Pa.}$$

(c)

Work done on the atmosphere in stretching the radius of the bubble from r to $r+\Delta r$ is

$$\Delta W = 4\pi r^2 \Delta r\, p_0 \;.$$

Therefore,

$$W = 4\pi p_0 \int_{r_i}^{r_f} r^2 dr = \frac{4\pi p_0}{3}\left(r_f^{\,3} - r_i^3\right).$$

On substituting the values for the atmospheric pressure p_0, r_f and r_i, we find

$$W = \frac{4\pi}{3}\left(5.80^3 - 3.20^3\right)\times 10^{-6}\times 1.01\times 10^5 = 68.7 \text{ J.}$$

(d)

Work done in stretching each bubble surface is

$$w = 4\pi\left(r_f^{\,2} - r_i^2\right)\gamma$$

$$= 4\pi\left(5.80^2 - 3.20^2\right)\times 10^{-4}\times 26\times 10^{-3} \text{ J}=765\mu\text{J.}$$