**205.**

**Problem 23.11 (RHK)**

*An air bubble of* $19.4 \text{ cm}^3$ *volume is at the bottom of a lake 41.5 m deep where the temperature is* $3.8^0\text{C}$. *The bubble rises to the surface, which is at a temperature of* $22.6^0\text{C}$. *We can take the temperature of the bubble to be the same as that of the surrounding water. We have to find its volume just before it reaches the surface.*

**Solution:**

We shall first calculate the amount of air in the bubble. Let it be n mol. Pressure of air at a depth of 41.5 m will be

$$
\begin{aligned}
P &= P_{atm} + \rho g h, \\
&= \left(1.01\times10^5 + 41.5\times9.8\times10^3\right)\text{Pa} \\
&= 5.07\times10^5 \text{ Pa.}
\end{aligned}
$$

It is given that the volume of the air bubble at the bottom of the lake that is at a depth of 41.5 m is

$$V = 19.4\times10^{-6} \text{ m}^3 .$$

Temperature of the lake at that depth is $3.8^0\text{C}$. Therefore the initial temperature of the bubble is

$$T = 276.96 \text{ K}.$$

Assuming the ideal gas equation for the air in the bubble, we can find the amount of gas in the bubble,

$$n = \frac{PV}{RT} = \frac{5.07\times10^5 \times 19.4\times10^{-6}}{8.3145\times 276.96} \text{ mol} = 4.27\times10^{-3} \text{ mol.}$$

Therefore, the volume of this air bubble, $V'$, just before it reaches the surface of the lake, where the temperature is $22.6^0\text{C}$ $(T' = 295.76 \text{ K})$, will be

$$V' = \frac{nRT'}{P_{atm}} = \frac{4.27\times10^{-3}\times 8.3145\times 295.76}{1.01\times10^5} \text{ m}^3$$

$$= 103.96\times10^{-6} \text{ m}^3 = 104 \text{ cm}^3 .$$