

$$\Rightarrow (l_0 \alpha (F_e) - d_0 \alpha (A_e)) \Delta t = d_0 - l_0 \quad (14)$$

$$-14x = 3 \quad (14)$$

$$\Rightarrow \Delta t = \frac{d_0 - l_0}{l_0 \alpha (F_e) - d_0 \alpha (A_e)} = \frac{80,00 \text{ mm} - 79,30 \text{ mm}}{79,30 \text{ mm} \cdot 11,7 \cdot 10^{-6} \frac{1}{^\circ\text{C}} - 80,00 \text{ mm} \cdot 23,2 \cdot 10^{-6} \frac{1}{^\circ\text{C}}}$$

$$= -108,56^\circ\text{C} \approx -109^\circ\text{C}$$

$$\Rightarrow \text{lämpötilassa: } t = t_0 + \Delta t = 20^\circ\text{C} + (-109^\circ\text{C}) = \underline{-89^\circ\text{C}}$$

$$\begin{array}{|c|} \hline A_0 \\ \hline a_0 \\ \hline \end{array} \quad l_0$$

$$\begin{array}{|c|} \hline A \\ \hline a \\ \hline \end{array} \quad l$$

$$A = a l = a_0 (1 + \alpha \Delta t) \cdot l_0 (1 + \alpha \Delta t)$$

$$= \underbrace{a_0 l_0}_{A_0} (1 + \alpha \Delta t)^2$$

$$= A_0 (1 + 2\alpha \Delta t + \underbrace{\alpha^2 \Delta t^2}_{\approx 0 \text{ koska } \alpha \text{ pieni}})$$

$$= A_0 (1 + \underbrace{2\alpha \Delta t}_{=\beta}) = A_0 (1 + \beta \Delta t)$$

PINTA-ALA

$$A = A_0 (1 + \beta \Delta t)$$

$$\beta \approx 2\alpha$$

TILAVUUS

$$V = V_0 (1 + \gamma \Delta t)$$

$$\gamma \approx 3\alpha \text{ kiertäille aineille}$$