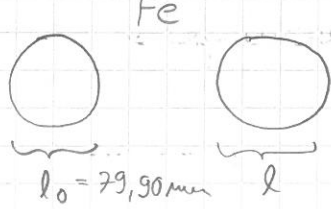
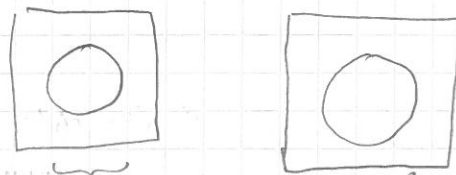


b)



$$\alpha_{Fe} = 11,7 \cdot 10^{-6} \frac{1}{^\circ C}$$

Al



$$d_0 = 80,00 \text{ mm}$$

$$\alpha_{Al} = 23,2 \cdot 10^{-6} \frac{1}{^\circ C}$$

$\alpha_{Al} > \alpha_{Fe} \Rightarrow$ alumiinin kera suurempi lämpölaajeneminen
 \Rightarrow lämpötila on alumiinissa

Tasatellen rajoituneissa:

$$l = d$$

$$\Rightarrow l_0 (1 + \alpha_{Fe} \Delta t) = d_0 (1 + \alpha_{Al} \Delta t)$$

$$\Rightarrow l_0 + l_0 \alpha_{Fe} \Delta t = d_0 + d_0 \alpha_{Al} \Delta t$$

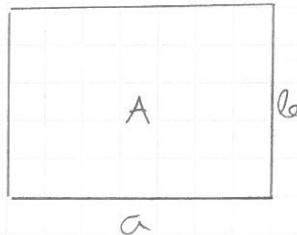
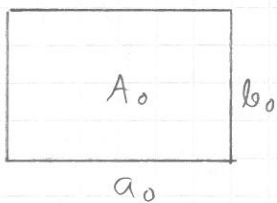
$$\Rightarrow l_0 \alpha_{Fe} \Delta t - d_0 \alpha_{Al} \Delta t = d_0 - l_0$$

$$\Rightarrow \Delta t (l_0 \alpha_{Fe} - d_0 \alpha_{Al}) = d_0 - l_0 \quad | : ()$$

$$\Rightarrow \Delta t = \frac{d_0 - l_0}{l_0 \alpha_{Fe} - d_0 \alpha_{Al}}$$

$$= \frac{80,00 \text{ mm} - 79,90 \text{ mm}}{79,90 \text{ mm} \cdot 11,7 \cdot 10^{-6} \frac{1}{^\circ C} - 80,00 \text{ mm} \cdot 23,2 \cdot 10^{-6} \frac{1}{^\circ C}} = -108,56^\circ C$$

$$\Rightarrow \text{lämpötilassa: } t = t_0 + \Delta t = 20^\circ C - 108,56^\circ C = \underline{-89^\circ C}$$



$$\begin{aligned} A &= a b = a_0 (1 + \alpha \Delta t) \cdot b_0 (1 + \alpha \Delta t) \\ &= a_0 b_0 (1 + \alpha \Delta t)^2 \\ &= \underbrace{a_0 b_0}_{A_0} (1 + 2\alpha \Delta t + \underbrace{\alpha^2 \Delta t^2}_{\approx 0 \text{ (algebra)}}) \\ &\approx A_0 (1 + \underbrace{2\alpha \Delta t}_\beta) \end{aligned}$$

PINTA-ALA

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

$$\beta = 2\alpha$$

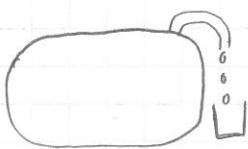
TILAVUUS

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

($\gamma = 3\alpha$ kiinteille aineille)

K 31

(K 25)



$$V_0 = 2100 \text{ l}, \quad \gamma_0 = 9,0 \cdot 10^{-4} \frac{1}{^\circ C}; \quad \Delta t = 35^\circ C$$

Öljyn tilavuus lopussa: $\alpha_t = 12 \cdot 10^{-6} \frac{1}{^\circ C}$

$$V_0 = V_0 (1 + \gamma_0 \Delta t) = 2100 \text{ l} \cdot (1 + 9,0 \cdot 10^{-4} \frac{1}{^\circ C} \cdot 35^\circ C) \approx 2166,15 \text{ l}$$

Terässäiliön tilavuus lopussa

$$V_t = V_0 (1 + \gamma_t \Delta t) = V_0 (1 + 3\alpha_t \Delta t) = 2100 \text{ l} (1 + 3 \cdot 12 \cdot 10^{-6} \frac{1}{^\circ C} \cdot 35^\circ C) \approx 2102,646 \text{ l}$$