

84. If the window is  $L_1$  high and  $L_2$  wide at the lower temperature and  $L_1 + \Delta L_1$  high and  $L_2 + \Delta L_2$  wide at the higher temperature then its area changes from  $A_1 = L_1 L_2$  to

$$A_2 = (L_1 + \Delta L_1)(L_2 + \Delta L_2) \approx L_1 L_2 + L_1 \Delta L_2 + L_2 \Delta L_1$$

where the term  $\Delta L_1 \Delta L_2$  has been omitted because it is much smaller than the other terms, if the changes in the lengths are small. Consequently, the change in area is

$$\Delta A = A_2 - A_1 = L_1 \Delta L_2 + L_2 \Delta L_1 .$$

If  $\Delta T$  is the change in temperature then  $\Delta L_1 = \alpha L_1 \Delta T$  and  $\Delta L_2 = \alpha L_2 \Delta T$ , where  $\alpha$  is the coefficient of linear expansion. Thus

$$\begin{aligned} \Delta A &= \alpha(L_1 L_2 + L_1 L_2) \Delta T = 2\alpha L_1 L_2 \Delta T \\ &= 2 (9 \times 10^{-6}/\text{C}^\circ) (30 \text{ cm})(20 \text{ cm})(30^\circ \text{C}) \\ &= 0.32 \text{ cm}^2 . \end{aligned}$$