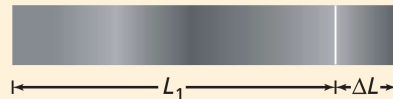


▶ EXAMPLE Problem 4

Linear Expansion A metal bar is 1.60 m long at room temperature, 21°C. The bar is put into an oven and heated to a temperature of 84°C. It is then measured and found to be 1.7 mm longer. What is the coefficient of linear expansion of this material?

1 Analyze and Sketch the Problem

- Sketch the bar, which is 1.7 mm longer at 84°C than at 21°C.
- Identify the initial length of the bar, L_1 , and the change in length, ΔL .



Known:

$$\begin{aligned}L_1 &= 1.60 \text{ m} \\ \Delta L &= 1.7 \times 10^{-3} \text{ m} \\ T_1 &= 21^\circ\text{C} \\ T_2 &= 84^\circ\text{C}\end{aligned}$$

Unknown:

$$\alpha = ?$$

2 Solve for the Unknown

Calculate the coefficient of linear expansion using the known length, change in length, and change in temperature.

$$\begin{aligned}\alpha &= \frac{\Delta L}{L_1 \Delta T} \\ &= \frac{1.7 \times 10^{-3} \text{ m}}{(1.60 \text{ m})(84^\circ\text{C} - 21^\circ\text{C})} && \text{Substitute } \Delta L = 1.7 \times 10^{-3} \text{ m}, L_1 = 1.60 \text{ m}, \\ & && \Delta T = (T_2 - T_1) = 84^\circ\text{C} - 21^\circ\text{C} \\ &= 1.7 \times 10^{-5} \text{ }^\circ\text{C}^{-1}\end{aligned}$$

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3 Evaluate the Answer

- **Are the units correct?** The units are correctly expressed in $^\circ\text{C}^{-1}$.
- **Is the magnitude realistic?** The magnitude of the coefficient is close to the accepted value for copper.

▶ PRACTICE Problems

Additional Problems, Appendix B

39. A piece of aluminum house siding is 3.66 m long on a cold winter day of -28°C . How much longer is it on a very hot summer day at 39°C ?
40. A piece of steel is 11.5 cm long at 22°C . It is heated to 1221°C , close to its melting temperature. How long is it?
41. A 400-mL glass beaker at room temperature is filled to the brim with cold water at 4.4°C . When the water warms up to 30.0°C , how much water will spill from the beaker?
42. A tank truck takes on a load of 45,725 L of gasoline in Houston, where the temperature is 28.0°C . The truck delivers its load in Minneapolis, where the temperature is -12.0°C .
 - a. How many liters of gasoline does the truck deliver?
 - b. What happened to the gasoline?
43. A hole with a diameter of 0.85 cm is drilled into a steel plate. At 30.0°C , the hole exactly accommodates an aluminum rod of the same diameter. What is the spacing between the plate and the rod when they are cooled to 0.0°C ?
44. A steel ruler is marked in millimeters so that the ruler is absolutely correct at 30.0°C . By what percentage would the ruler be incorrect at -30.0°C ?