4. (a) Let the reading on the Celsius scale be x and the reading on the Fahrenheit scale be y. Then $y = \frac{9}{5}x + 32$. If we require $y = 2x$, then we have

$$2x = \frac{9}{5}x + 32 \implies x = (5)(32) = 160°\text{C}$$

which yields $y = 2x = 320°\text{F}$.

(b) In this case, we require $y = \frac{1}{2}x$ and find

$$\frac{1}{2}x = \frac{9}{5}x + 32 \implies x = -\frac{(10)(32)}{13} \approx -24.6°\text{C}$$

which yields $y = x/2 = -12.3°\text{F}$.

12. (a) The coefficient of linear expansion α for the alloy is

$$\alpha = \Delta L / L \Delta T = \frac{10.015\,\text{cm} - 10.000\,\text{cm}}{(10.01\,\text{cm})(100°\text{C} - 20.000°\text{C})} = 1.88 \times 10^{-5}/\text{C}° \ .$$

Thus, from 100°C to 0°C we have

$$\Delta L = L\alpha\Delta T = (10.015\,\text{cm})\left(1.88 \times 10^{-5}/\text{C}°\right)(0°\text{C} - 100°\text{C}) = -1.88 \times 10^{-2}\ \text{cm} \ .$$

The length at 0°C is therefore $L' = L + \Delta L = 10.015\,\text{cm} - 0.0188\,\text{cm} = 9.996\,\text{cm}$.

(b) Let the temperature be T_x. Then from 20°C to T_x we have

$$\Delta L = 10.009\,\text{cm} - 10.000\,\text{cm} = \alpha L \Delta T = (1.88 \times 10^{-5}/\text{C}°)(10.000\,\text{cm})\Delta T \ ,$$

giving $\Delta T = 48\,\text{C}°$. Thus, $T_x = 20°\text{C} + 48\,\text{C}° = 68°\text{C}$.

29. The melting point of silver is 1235 K, so the temperature of the silver must first be raised from 15.0°C (= 288 K) to 1235 K. This requires heat

$$Q = cm(T_f - T_i) = (236\,\mathrm{J/kg\cdot K})(0.130\,\mathrm{kg})(1235^\circ\mathrm{C} - 288^\circ\mathrm{C}) = 2.91 \times 10^4\,\mathrm{J}\ .$$

Now the silver at its melting point must be melted. If L_F is the heat of fusion for silver this requires

$$Q = mL_F = (0.130\,\mathrm{kg})(105 \times 10^3\,\mathrm{J/kg}) = 1.36 \times 10^4\,\mathrm{J}\ .$$

The total heat required is $2.91 \times 10^4\,\mathrm{J} + 1.36 \times 10^4\,\mathrm{J} = 4.27 \times 10^4\,\mathrm{J}$.

51. Over a cycle, the internal energy is the same at the beginning and end, so the heat Q absorbed equals the work done: $Q = W$. Over the portion of the cycle from A to B the pressure p is a linear function of the volume V and we may write

$$p = \frac{10}{3}\,\text{Pa} + \left(\frac{20}{3}\,\text{Pa/m}^3\right) V\,,$$

where the coefficients were chosen so that $p = 10\,\text{Pa}$ when $V = 1.0\,\text{m}^3$ and $p = 30\,\text{Pa}$ when $V = 4.0\,\text{m}^3$. The work done by the gas during this portion of the cycle is

$$\begin{aligned} W_{AB} &= \int_1^4 p\,dV = \int_1^4 \left(\frac{10}{3} + \frac{20}{3}V\right) dV = \left(\frac{10}{3}V + \frac{10}{3}V^2\right)\Big|_1^4 \\ &= \frac{40}{3} + \frac{160}{3} - \frac{10}{3} - \frac{10}{3} = 60\ \text{J}\,. \end{aligned}$$

The BC portion of the cycle is at constant pressure and the work done by the gas is $W_{BC} = p\,\Delta V = (30\,\text{Pa})(1.0\,\text{m}^3 - 4.0\,\text{m}^3) = -90\,\text{J}$. The CA portion of the cycle is at constant volume, so no work is done. The total work done by the gas is $W = W_{AB} + W_{BC} + W_{CA} = 60\,\text{J} - 90\,\text{J} + 0 = -30\,\text{J}$ and the total heat absorbed is $Q = W = -30\,\text{J}$. This means the gas loses 30 J of energy in the form of heat.

57. The rate of heat flow is given by

$$P_{\rm cond} = kA\,\frac{T_H - T_C}{L}\,,$$

where k is the thermal conductivity of copper ($401\,{\rm W/m\cdot K}$), A is the cross-sectional area (in a plane perpendicular to the flow), L is the distance along the direction of flow between the points where the temperature is T_H and T_C. Thus,

$$P_{\rm cond} = \frac{(401\,{\rm W/m\cdot K})(90.0\times 10^{-4}\,{\rm m}^2)(125^\circ{\rm C} - 10.0^\circ{\rm C})}{0.250\,{\rm m}} = 1.66\times 10^3\ {\rm J/s}\ .$$

The thermal conductivity is found in Table 19-6 of the text. Recall that a change in Kelvin temperature is numerically equivalent to a change on the Celsius scale.