19.13 This problem asks that we calculate the values of  $c_v$  for aluminum and iron at room temperature using Equation 19.10, the data in Table 19.1, given that  $\alpha_v = 3\alpha_l$ , and also values of the compressibility. From Equation 19.10

$$c_v = c_p - \frac{\alpha_v^2 v_0 T}{\beta}$$

And, from Table 19.1 and the problem statement

$$c_p(AI) = 900 \text{ J/kg-K}$$
  
 $c_p(Fe) = 448 \text{ J/kg-K}$   
 $\alpha_v(AI) = (3)[23.6 \text{ x } 10^{-6} (^{\circ}\text{C})^{-1}] = 7.08 \text{ x } 10^{-5} (^{\circ}\text{C})^{-1}$   
 $\alpha_v(Fe) = (3)[(11.8 \text{ x } 10^{-6} (^{\circ}\text{C})^{-1}] = 3.54 \text{ x } 10^{-5} (^{\circ}\text{C})^{-1}$   
 $\beta(AI) = 1.77 \text{ x } 10^{-11} (Pa)^{-1}$   
 $\beta(Fe) = 2.65 \text{ x } 10^{-12} (Pa)^{-1}$ 

The specific volume is just the reciprocal of the density; thus, in units of m<sup>3</sup>/kg

$$v_0(\text{Al}) = \frac{1}{\rho} = \left(\frac{1}{2.71 \text{ g/cm}^3}\right) \left(\frac{1000 \text{ g}}{\text{kg}}\right) \left(\frac{1 \text{ m}}{100 \text{ cm}}\right)^3 = 3.69 \text{ x } 10^{-4} \text{ m}^3/\text{kg}$$
$$v_0(\text{Fe}) = \left(\frac{1}{7.87 \text{ g/cm}^3}\right) \left(\frac{1000 \text{ g}}{\text{kg}}\right) \left(\frac{1 \text{ m}}{100 \text{ cm}}\right)^3 = 1.27 \text{ x } 10^{-4} \text{ m}^3/\text{kg}$$

Therefore, for aluminum

$$c_{\nu}(\text{Al}) = c_{p}(\text{Al}) - \frac{\alpha_{\nu}^{2}(\text{Al}) v_{0}(\text{Al})T}{\beta(\text{Al})}$$
  
= 900 J/kg-K - 
$$\frac{\left[7.08 \text{ x } 10^{-5} (^{\circ}\text{C})^{-1}\right]^{2} (3.69 \text{ x}10^{-4} \text{ m}^{3}/\text{kg}) (293 \text{ K})}{1.77 \text{ x } 10^{-11} (\text{N/m}^{2})^{-1}}$$

= 869 J/kg-K

And, also for iron

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