18.56. Solve: **(a)** The thermal energy of a monatomic gas of n_1 moles is $E_1 = \frac{3}{2} n_1 RT$. The thermal energy of a diatomic gas of n_2 moles is $E_2 = \frac{5}{2} n_2 RT$. The total thermal energy of the mixture is

$$E_{\text{th}} = \tfrac{1}{2}\left(3n_1 + 5n_2\right)RT \Rightarrow \Delta E_{\text{th}} = \tfrac{1}{2}\left(3n_1 + 5n_2\right)R\Delta T$$

Comparing this expression with

$$\Delta E_{\text{th}} = n_{\text{total}}\, C_{\text{V}} \Delta T = \left(n_1 + n_2\right)C_{\text{V}}\Delta T$$

we get

$$C_{\text{V}} = \frac{\left(3n_1 + 5n_2\right)}{2\left(n_1 + n_2\right)} R$$

(b) For a diatomic gas, $n_1 \to 0$, and $C_{\text{V}} = \frac{5}{2} R$. For a monotomic gas, $n_2 \to 0$, and $C_{\text{V}} = \frac{3}{2} R$.