TABLE 2-2
Approximate Forms of the Energy Conservation Equation in Rectangular, Cylindrical, and Spherical Coordinates (Thermal Effects Only)[a]

Rectangular: $T = T(x, y, z, t)$

$$\frac{\partial T}{\partial t} + v_x \frac{\partial T}{\partial x} + v_y \frac{\partial T}{\partial_y} + v_z \frac{\partial T}{\partial z} = \alpha\left[\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}\right] + \frac{H_V}{\rho \hat{C}_P}$$

Cylindrical: $T = T(r, \theta, z, t)$

$$\frac{\partial T}{\partial t} + v_r \frac{\partial T}{\partial r} + \frac{v_\theta}{r}\frac{\partial T}{\partial \theta} + v_z \frac{\partial T}{\partial z} = \alpha\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 T}{\partial \theta^2} + \frac{\partial^2 T}{\partial z^2}\right] + \frac{H_V}{\rho \hat{C}_P}$$

Spherical: $T = T(r, \theta, \phi, t)$

$$\frac{\partial T}{\partial t} + v_r \frac{\partial T}{\partial r} + \frac{v_\theta}{r}\frac{\partial T}{\partial \theta} + \frac{v_\phi}{r \sin\theta}\frac{\partial T}{\partial \phi} = \alpha\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial T}{\partial \theta}\right) + \frac{1}{r^2 \sin^2\theta}\frac{\partial^2 T}{\partial \phi^2}\right] + \frac{H_V}{\rho \hat{C}_P}$$

[a] It is assumed that ρ, $\hat{C}_p$, and k are constant and that certain mechanical effects are negligible. The thermal diffusivity is $\alpha = k/(\rho\hat{C}_p)$. More general energy equations are given in Section 9.6 for pure fluids and in Section 11.2 for mixtures.

TABLE 2-3
Species Conservation Equations for a Binary or Pseudobinary Mixture in Rectangular, Cylindrical, and Spherical Coordinates[a]

Rectangular: $C_i = C_i(x, y, z, t)$

$$\frac{\partial C_i}{\partial t} + v_x \frac{\partial C_i}{\partial x} + v_y \frac{\partial C_i}{\partial y} + v_z \frac{\partial C_i}{\partial z} = D_i\left[\frac{\partial^2 C_i}{\partial x^2} + \frac{\partial^2 C_i}{\partial y^2} + \frac{\partial^2 C_i}{\partial z^2}\right] + R_{Vi}$$

Cylindrical: $C_i = C_i(r, \theta, z, t)$

$$\frac{\partial C_i}{\partial t} + v_r \frac{\partial C_i}{\partial r} + \frac{v_\theta}{r}\frac{\partial C_i}{\partial \theta} + v_z \frac{\partial C_i}{\partial z} = D_i\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial C_i}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 C_i}{\partial \theta^2} + \frac{\partial^2 C_i}{\partial z^2}\right] + R_{Vi}$$

Spherical: $C_i = C_i(r, \theta, \phi, t)$

$$\frac{\partial C_i}{\partial t} + v_r \frac{\partial C_i}{\partial r} + \frac{v_\theta}{r}\frac{\partial C_i}{\partial \theta} + \frac{v_\phi}{r \sin\theta}\frac{\partial C_i}{\partial \phi} = D_i\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial C_i}{\partial r}\right) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial C_i}{\partial \theta}\right) + \frac{1}{r^2 \sin^2\theta}\frac{\partial^2 C_i}{\partial \phi^2}\right] + R_{Vi}$$

[a] It is assumed that ρ and D_i are constant, where D_i is the binary or pseudobinary diffusivity.