Thermodynamics

2 The First Law of Thermodynamics

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$$U_A = U_B$$

$$U_B - U_A = -L \tag{1}$$

$$U_O = 0 \tag{2}$$

$$U_A = -L_A \tag{3}$$

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$$L = -L_A + L_B$$

$$U_B = -L_B$$

$$U_B - U_A = -L$$

title

$$L'_A = L_{O'O} + L_A$$

$$U_A = -L_A; \quad U'_A = -L'_A$$

$$U_A - U'_A = L_{O'O}$$

title

$$\Delta U + L = 0 \tag{4}$$

$$\Delta U + L = Q \tag{5}$$

$$\Delta U = -L + Q$$

$$L = Q \tag{6}$$

$$\Delta U_c = m\Delta u_c; \quad L_c = m l_c \tag{7}$$

$$\Delta U = \Delta U_S + \Delta U_c$$

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$$L = L_S + L_c$$

$$\Delta U_S + \Delta U_c + L_S + L_c = 0$$

$$\begin{aligned} \Delta U_S + L_S &= -(\Delta U_c + L_c) \\ &= -m(\Delta U_c + l_c) \end{aligned}$$

$$Q_S = -m(\Delta U_c + l_c) \tag{8}$$

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$$1 \text{ calorie} = 4.185 \times 10^7 \text{ ergs} \tag{9}$$

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$$dU + dL = dQ \tag{10}$$

$$dU + pdV = dQ \tag{11}$$

$$dU = \left(\frac{\partial U}{\partial T}\right)_V dT + \left(\frac{\partial U}{\partial V}\right)_T dV$$

title

$$\left(\frac{\partial U}{\partial T}\right)_V dT + \left[\left(\frac{\partial U}{\partial V}\right)_T + p\right] dV = dQ \tag{12}$$

$$\left[\left(\frac{\partial U}{\partial T}\right)_p + p\left(\frac{\partial V}{\partial T}\right)_p\right] dT + \left[\left(\frac{\partial U}{\partial p}\right)_T + p\left(\frac{\partial V}{\partial p}\right)_T\right] dp = dQ \tag{13}$$

$$\left(\frac{\partial U}{\partial p}\right)_V dp + \left[\left(\frac{\partial U}{\partial V}\right)_p + p\right] dV = dQ \tag{14}$$

title

$$C_V = \left(\frac{dQ}{dT}\right)_V = \left(\frac{\partial U}{\partial T}\right)_T \tag{15}$$

$$C_p = \left(\frac{dQ}{dT}\right)_p = \left(\frac{\partial U}{\partial T}\right)_p + p\left(\frac{\partial V}{\partial T}\right)_p \tag{16}$$

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$$\Delta U + L = 0$$

$$\Delta U = 0$$

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$$C_V = \frac{dU}{dT} \tag{17}$$

$$U = C_V T + W \tag{18}$$

$$C_V dT + pdV = dQ \tag{19}$$

$$pdV + V dp = RdT \tag{20}$$

$$(C_V + R)dT - V\,dp = qQ \tag{21}$$

$$C_p = \left(\frac{dQ}{dT}\right)_p = C_V + R \tag{22}$$

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$$\left(\frac{\partial U}{\partial T}\right)_p \frac{dU}{dT} = C_V; \quad \left(\frac{\partial V}{\partial T}\right)_p = \left(\frac{\partial}{\partial T}\frac{RT}{p}\right)_p = \frac{R}{p} \tag{23}$$

$$
\begin{aligned}
C_V &= \frac{3}{2}R \text{ (for a monatomic gas)} \\
C_V &= \frac{5}{2}R \text{ (for a diatomic gas)}
\end{aligned}
\tag{24}
$$

$$
\begin{aligned}
C_p &= \frac{5}{2}R \text{ (for a monatomic gas)} \\
C_p &= \frac{7}{2}R \text{ (for a diatomic gas)}
\end{aligned}
\tag{25}
$$

title

$$K = \frac{C_p}{C_V} = \frac{C_V + R}{C_V} = 1 + \frac{R}{C_V'} \tag{26}$$

$$\begin{aligned} K &= \frac{5}{3} \text{ (for a monatomic gas)} \\ K &= \frac{7}{5} \text{ (for a diatomic gas)} \end{aligned} \tag{27}$$

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$$C_V dT + p dV = 0$$

$$\begin{aligned} C_V dT + \frac{RT}{V} dV &= 0 \\ \frac{dT}{T} + \frac{R}{C_V} \frac{dV}{V} &= 0 \end{aligned}$$

$$\ln T + \frac{R}{C_V} \ln V = \text{constant.}$$

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$$TV^{\frac{R}{C_V}} = \text{constant.}$$

$$TV^{\frac{K-1}{K}} = \text{constant.} \tag{28}$$

title

$$pV^K = \text{constant}. \tag{29}$$

$$\frac{T}{p^{\frac{K-1}{K}}} = \text{constant}. \tag{30}$$

$$pV = \text{constant}.$$

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$$dp = -\rho g dh \tag{31}$$

$$dp = -\frac{gM}{R}\frac{p}{T}dh$$

$$\frac{dT}{T} = \frac{K-1}{K}\frac{dp}{p}$$

$$\frac{dT}{dh} = -\frac{K-1}{K}\frac{gM}{R} \tag{32}$$

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$$K = \frac{7}{5};\ \ g = 980.665;\ \ M = 28.88;\ \ R = 8.214 \times 10^7$$

$$\begin{aligned}\frac{dT}{dh} &= -9.8 \times 10^{-5} \text{ degrees/cm} \\ &= -9.8 \text{ degrees/kilometer}\end{aligned}$$