EQUATIONS
Conservation of Energy

$$\Delta E = Q - W \tag{1}$$

$$\frac{dE}{dt} = \dot{Q} - \dot{W} \tag{2}$$

$$\frac{dE_{C.V.}}{dt} = \dot{Q}_{C.V.} - \dot{W}_{C.V.} + \sum_i \dot{m}_i\left(h_i + \frac{V_i^2}{2} + gz_i\right) - \sum_e \dot{m}_e\left(h_e + \frac{V_e^2}{2} + gz_e\right) \tag{3}$$

Entropy Balance

$$\Delta S = \int_1^2 \left(\frac{\delta Q}{T}\right)_b + \sigma \tag{4}$$

$$\Delta S = \sum_j \frac{Q_j}{T_j} + \sigma \tag{5}$$

$$\frac{dS}{dt} = \sum_j \frac{\dot{Q}_j}{T_j} + \dot{\sigma} \tag{6}$$

$$\frac{dS_{C.V.}}{dt} = \sum_j \frac{\dot{Q}_j}{T_j} + \sum_i \dot{m}_i s_i - \sum_e \dot{m}_e s_e + \dot{\sigma}_{C.V.} \tag{7}$$

$$v = (1-x)v_f + xv_g \tag{8}$$

$$\overline{R} = 8.314 \text{kJ/kmol} \cdot \text{K} \tag{9}$$

$$c_p = \left(\frac{\partial h}{\partial T}\right)_p \qquad c_v = \left(\frac{\partial u}{\partial T}\right)_v \tag{10}$$

$$\eta = \frac{W_{cycle}}{Q_H} = 1 - \frac{Q_C}{Q_H} \qquad \beta = \frac{Q_C}{Q_H - Q_C} \qquad \gamma = \frac{Q_H}{Q_H - Q_C} \tag{11}$$

$$\eta_{max} = 1 - \frac{T_C}{T_H} \tag{12}$$

$$Tds = du + pdv \qquad Tds = dh - vdp \tag{13}$$

$$\eta_t = \frac{\dot{W}/\dot{m}}{(\dot{W}/\dot{m})_s} \qquad \eta_c = \frac{(\dot{W}/\dot{m})_s}{\dot{W}/\dot{m}} \qquad \eta_{nozzle} = \frac{V^2/2}{(V^2/2)_s} \tag{14}$$

Isentropic Relations, Ideal Gas

$$\frac{p_2}{p_1} = \frac{p_{r2}}{p_{r1}} \qquad \frac{v_2}{v_1} = \frac{v_{r2}}{v_{r1}} \tag{15}$$

Isentropic Relations, Ideal Gas, Constant Specific Heats

$$\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{k-1}{k}} \qquad \frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{k-1} \tag{16}$$

Ideal Gas

$$c_p = \frac{kR}{k-1} \qquad c_v = \frac{R}{k-1} \tag{17}$$

$$\Delta\bar{s} = \bar{s}^\circ(T_2) - \bar{s}^\circ(T_1) - \overline{R}\ln\frac{p_2}{p_1} \tag{18}$$

$$\Delta\bar{s} = \bar{c}_p \ln\frac{T_2}{T_1} - \overline{R}\ln\frac{p_2}{p_1} \quad \text{(only for constant specific heats)} \tag{19}$$

Chapter 12

$$\omega = \frac{m_v}{m_a} = 0.622\frac{p_v}{p - p_v} \tag{20}$$

$$\phi = \frac{p_v}{p_g} \tag{21}$$

Chapter 13

$$\bar{h}(T,p) = \bar{h}_f^\circ + \Delta\bar{h} \tag{22}$$

$$\bar{s}(T,p) = \bar{s}^\circ(T) - \overline{R}\ln\frac{p}{p_{ref}} \quad \text{(ideal gas)} \tag{23}$$

$$\bar{g}(T,p) = \bar{g}_f^\circ + \Delta\bar{g} \tag{24}$$

Chapter 14

$$-\frac{\Delta G^\circ}{\overline{R}T} = \ln\left[\frac{{y_C}^{\nu_C}{y_D}^{\nu_D}}{{y_A}^{\nu_A}{y_B}^{\nu_B}}\left(\frac{p}{p_{ref}}\right)^{\nu_C+\nu_D-\nu_A-\nu_B}\right] \tag{25}$$

$$\Delta G^\circ = \nu_C(\overline{h}_C - T\overline{s}^\circ_C) + \nu_D(\overline{h}_D - T\overline{s}^\circ_D) - \nu_A(\overline{h}_A - T\overline{s}^\circ_A) - \nu_B(\overline{h}_B - T\overline{s}^\circ_B) \tag{26}$$

$$-\frac{\Delta G^\circ}{\overline{R}T} = \ln K(T) \tag{27}$$

$$K(T) = \frac{{y_C}^{\nu_C}{y_D}^{\nu_D}}{{y_A}^{\nu_A}{y_B}^{\nu_B}}\left(\frac{p}{p_{ref}}\right)^{\nu_C+\nu_D-\nu_A-\nu_B} \tag{28}$$
