

$w = \int P\, dv$ Quasi-equilibrium (reversible) process;

$h = u + Pv$ Definition, always true

$PV = mRT = n\bar{R}T$ Ideal gas ($T > 2*T_{crit}$, $P < 10$ MPa)

$u \approx u_f @ T$; $v \approx v_f @ T$ Subcooled liquid

$Q - W = E_2 - E_1$ First law for a process, no constraints

$Q - W = U_2 - U_1$ First law for a process, closed system, negligible changes in kinetic and potential energy

$C_v = \frac{\partial u}{\partial T}$, $C_p = \frac{\partial h}{\partial T}$ Definition;

$C_v = \frac{du}{dT}$, $C_p = \frac{dh}{dT}$ u and h functions of temperature only

$u_2 - u_1 = \int C_v\, dT$ Internal energy is a function of temp only;

$h_2 - h_1 = \int C_p\, dT$ Enthalpy is a function of temp only

$\oint \delta Q = \oint \delta W$ Any thermodynamic cycle

$\dot{m} = \rho \vec{V} A$ steady, 1-d flow

$\dot{Q} + \sum \dot{m}_i(h + \frac{\vec{V}^2}{2} + gZ)_i = \dot{W} + \sum \dot{m}_e(h + \frac{\vec{V}^2}{2} + gZ)_e + \frac{dE}{dt}$ First law for control volume

$q + h_1 + \frac{1}{2}\vec{V}_1^2 + gZ_1 = w + h_2 + \frac{1}{2}\vec{V}_2^2 + gZ_2$ Single-inlet, single-exit, steady flow

$\eta_{th} = \frac{w_{net}}{q_H} = 1 - \frac{q_L}{q_H}$ Heat engine; $\beta = \frac{q_L}{w_{net}}$ Heat pump (cooler); $\gamma = \frac{q_H}{w_{net}}$ Heat pump (heater)

$w = -\int v\, dP - \frac{1}{2}(\vec{V}_2^2 - \vec{V}_1^2) - g(Z_2 - Z_1)$ Reversible, steady flow

$q = \int T ds$ Reversible process

$Pv^n = \text{constant}$ Polytropic process (ideal gas) ($n = 0, P = c$; $n = 1, T = c$; $n = k, s = c$; $n \to \infty, v = c$)

$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$; $\frac{T_2}{T_1} = \left(\frac{v_2}{v_1}\right)^{1-k}$; $\frac{P_2}{P_1} = \left(\frac{v_1}{v_2}\right)^{k}$ Isentropic, ideal gas, constant specific heats

$\Delta s = C_p \ln\frac{T_2}{T_1} - R \ln\frac{P_2}{P_1}$, $\Delta s = C_v \ln\frac{T_2}{T_1} + R \ln\frac{v_2}{v_1}$ Ideal gas, constant specific heats

$\frac{P_{R2}}{P_{R1}} = \frac{P_2}{P_1}$; $\frac{v_{R2}}{v_{R1}} = \frac{v_2}{v_1}$ Isentropic, ideal gas, non-constant specific heats

$\eta_{turbine} = w_a/w_s$ $\eta_{compressor} = w_s/w_a$ $\eta_{pump} = w_s/w_a$ $\eta_{nozzle} = \frac{\vec{V}_a^2}{\vec{V}_s^2}$