Chapter 19  Thermodynamic Processes

These are for an ideal gas.

**In all cases:** \( \Delta U = Q - W \)

\( \Delta U \) change in gas internal energy

\( Q \) heat energy into gas

\( W \) work done by gas, thus if \( W \) is negative, work is done on gas

**Isochoric (Constant volume)**

\[ W = n C_v (T_2 - T_1) \]

**Isothermal (Constant temperature)**

\[ W = n C_v (T_2 - T_1) \]

**Adiabatic (Q = 0, no heat transfer)**

\[ \frac{p V^\gamma}{\gamma - 1} = \text{Constant} \]

\[ T V^{\gamma - 1} = \text{Constant} \]

\( \gamma = \frac{C_p}{C_v} \)

\[ T = \text{Constant} \]

\[ p^{\gamma - 1} = \text{Constant} \]

\[ W = n C_v (T_1 - T_2) \]

\[ W = \frac{C_v}{R} (p_1 V_1 - p_2 V_2) \]

\[ W = \frac{1}{\gamma - 1} (p_1 V_1 - p_2 V_2) \]

\[ \Delta U = -W \]

\[ \Delta U = n C_v (T_2 - T_1) \]
Note: for ideal gas $C_V = C_p - R$

Monatomic: $C_V = \frac{3}{2} R$, $C_p = \frac{5}{2} R$

Diatomic: $C_V = \frac{5}{2} R$, $C_p = \frac{7}{2} R$

Polyatomic: $C_V = 3R$, $C_p = 4R$

\[ \frac{C_V}{R} = \frac{C_V}{C_p - C_V} = \frac{1}{\gamma - 1} \]

**Isochoric (Constant Volume)**

\[ W = 0 \]
\[ Q = nC_V(T_2 - T_1) \]
\[ \Delta U = Q \]

**Isothermal (Constant temperature)**

Isothermal process

\[ W = \int p \, dV \quad pV = nRT \]
\[ p = \frac{nRT}{V} \]

\[ W = \int \frac{nRT}{V} \, dV = nRT \int \frac{dV}{V} = nRT \ln \left( \frac{V_2}{V_1} \right) \]
\[ = nRT \ln \left( \frac{p_1}{p_2} \right) \]

(Note: $T$ = Constant, $pV = nRT$ = Constant
Thus $p_1V_1 = p_2V_2$, $\frac{p_1}{p_2} = \frac{V_2}{V_1}$)

\[ \Delta U = 0 \]
\[ Q = W \]

Ideal Gas $pV = nRT$

\[ R = 8.314 \text{ J/mol K} = 0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1} \]
\[ 1 \text{ atm} = 1.013 \times 10^5 \text{ Pa} \]