Thermal Physics - PH441 **John Waczak**
Day 25 Date: May 25, 2018

Thermo Review

Quick review

$$Q = \int T dS$$
$$W = -\int p dV$$
$$\Delta U = Q + W$$

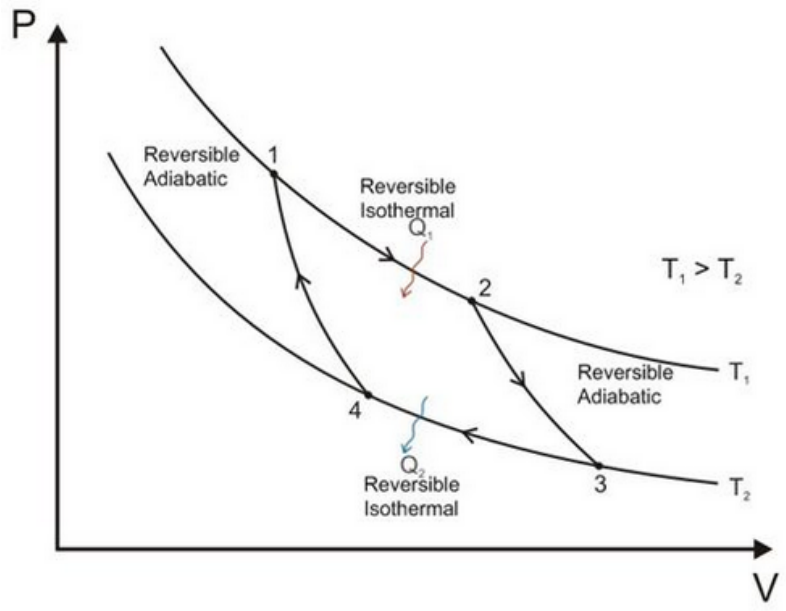
Ideal Gas Review

$$pV = NkT$$
$$U = \frac{3}{2}NkT$$
$$S = Nk\Big(\ln\Big(\frac{n_Q}{n}\Big) + \frac{5}{2}\Big)$$
$$F = NkT\Big(\ln\Big(\frac{n}{n_Q}\Big) - 1\Big)$$
$$n = n_Q e^{-\beta\mu}$$
$$n_Q = \Big(\frac{mkT}{2\pi\hbar^2}\Big)^{3/2}$$

Carnot Cycle

What is a Carnot Cycle? It is a cycle with 4 steps. Start at T_C the cold temperature.

1. Adiabatically (No Heat added) Compress until it is T_H
2. Isothermally (fixed T) expand (twice the volume)
3. Adiabatically expand to T_C
4. Isothermally compress to original volume



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\begin{aligned}
Q_1 = 0 \Rightarrow W_1 &= \Delta U_1 \\
&= \frac{3}{2} N k (T_H - T_C) \\
Q_3 = 0 \Rightarrow W_3 &= \frac{3}{2} N k (T_C - T_H) \\
Q_2 &= ? \\
W_2 \Rightarrow V_0 \rightarrow 2_V) &= 0 \\
W_2 &= -\int_{V_0}^{2V_0} \frac{1}{V} N k T_H \\
&= -N k T_H \ln(2) \\
S_{V_0} = S_{V_4} &\text{ and } S_{V_3} = S_{2V_0} \\
\Rightarrow V4 = \frac{1}{2} V_3 &\text{ from entropy equation} \\
\Rightarrow W_4 &= -N k T_C \ln(1/2) = N k T_C \ln(2) \\
W_{TOT} &= k \ln(2) \cdot (T_C - T_H)
\end{aligned}
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