

Ideal Gas Processes

<u>name</u>	<u>defined by</u>	<u>1st law result</u>	<u>work done</u>	<u>useful relations</u>
Isothermal	T=constant	$Q = -W \quad (\Delta U=0)$	$W = -NkT \ln(V_f/V_i)$	$PV = \text{constant}$
Isochoric (Constant Volume)	V=constant	$Q = \Delta U$	$W = 0$	$Q = C_V \Delta T$
Isobaric (Constant Pressure)	P=constant	$Q = \Delta U - W$	$W = -P(V_f - V_i)$	$Q = C_P \Delta T$
Adiabatic (Isoentropic)	Q=0 (S=constant)	$\Delta U = W$	$W = \frac{f}{2} Nk(T_f - T_i)$ $= (P_f V_f - P_i V_i) / (\gamma - 1)$	$PV^\gamma = \text{constant}$ $TV^{\gamma-1} = \text{constant}$

These results all derive from the 1st law $\Delta U=Q+W$ and the ideal gas properties $PV=NkT$ and $K_{\text{trans}} = \frac{3}{2} NkT$.

For a gas composed of spherically symmetric particles $U = K_{\text{trans}}$ but in the case of non-spherically symmetric particles we have $U = K_{\text{trans}} + K_{\text{rot}}$. In general $U = \frac{f}{2} NkT$ where f is the number of degrees of freedom of a gas molecule. [$f=3$ for monatomic gases, $f=5$ for diatomic gases, $f \geq 6$ for non-linear molecules]

Note that $C_v = \frac{f}{2} Nk$, $C_p = C_v + Nk$, and $\gamma = C_p/C_v = (f+2)/f$. For air (mainly N_2 and O_2) $\gamma \approx 7/5 \approx 1.4$.