Review

- **Work done by the gas:**

$$\boxed{W = \int_{V_i}^{V_f} p\,dV}$$

$pV = nRT$

+3 special cases:

<u>p = constant (isobaric):</u>

$$W = p\Delta V = p(V_f - V_i) = nR(T_f - T_i)$$

<u>V = constant (isochoric):</u>

$$W = 0$$

<u>T = constant (isothermal):</u>

$$W = nRT \ln \frac{V_f}{V_i}$$

- **Equation of State:**

$$pV = nRT$$

$$\frac{p_i V_i}{T_i} = \frac{p_f V_f}{T_f} = nR$$

- **The First Law of Thermodynamics:**

$$\Delta E_{\text{int}} = Q - W$$

Four Special Cases

Process	Restriction	Consequence
Adiabatic	$Q = 0$	$\Delta E_{int} = -W$
Constant volume	$W = 0$	$\Delta E_{int} = Q$
Closed cycle	$\Delta E_{int} = 0$	$Q = W$
Free expansion	$Q = W = 0$	$\Delta E_{int} = 0$

- **For a closed cycle:** $\Delta E_{\text{int}} = 0$

- **Work done by the gas:**

  - Expansion: $W > 0$

  - Compression: $W < 0$

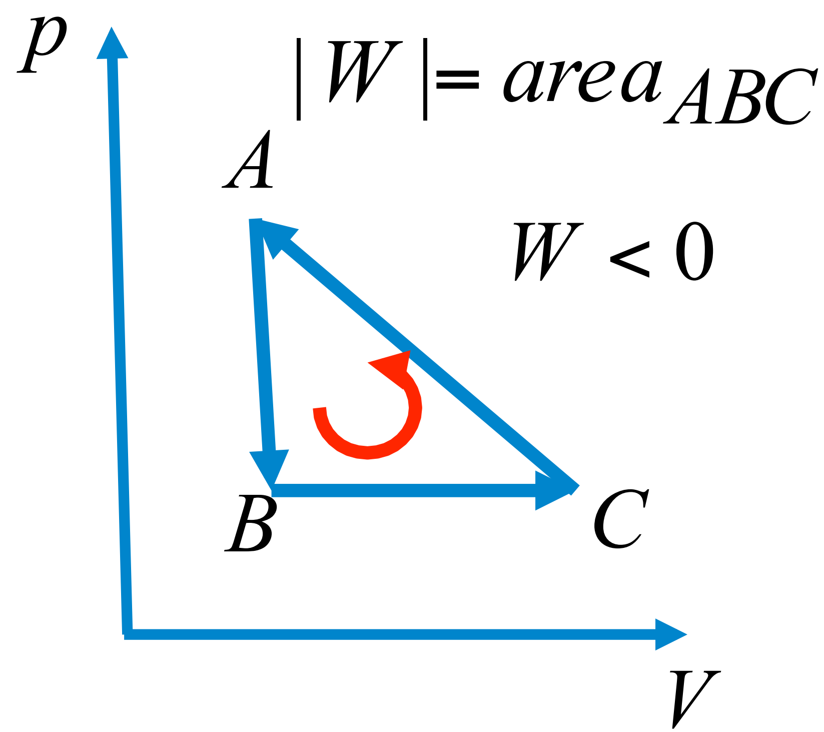
- **Energy transferred as heat Q:**

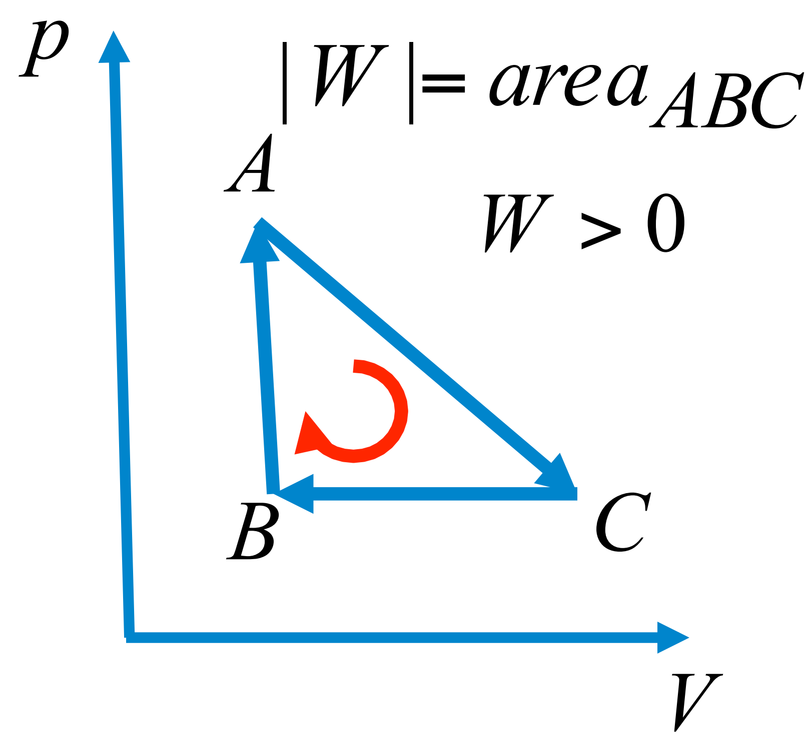
  - Heat transferred to the gas (receiving energy as heat):

$$Q > 0$$

  - Heat transferred from the gas (releasing energy as heat):

$$Q < 0$$





- **Isothermal process:**

$$\Delta E_{\text{int}} = 0$$

$$W = Q = nRT \ln \frac{V_f}{V_i}$$

- **RMS Speed:**

$$v_{rms} = \sqrt{\frac{3RT}{M}} \qquad \bar{v} = v_{avg} = \sqrt{\frac{8RT}{\pi M}}$$

- **Translational Kinetic Energy per Molecule:**

$$\overline{K} = \frac{3}{2} kT$$

- **Total Translational Kinetic Energy (n moles):**

$$K_{total} = \frac{3}{2} nRT$$

•**Mean Free Path:**

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 N/V} = \frac{kT}{\sqrt{2}\pi d^2 p}$$

•**The Change in Internal Energy:** $\Delta E_{\text{int}} = nC_V \Delta T$

•**Molar Specific Heats of an Ideal Gas:**

V = constant: $Q = nC_V \Delta T$

p = constant: $Q = nC_p \Delta T$

with $C_p = C_V + R$

•**Adiabatic Process (Q = 0):** pV^{γ} = constant; $TV^{\gamma-1} = \text{constant}$

$$\gamma = \frac{C_p}{C_V}; C_V = \frac{f}{2}R; C_p = C_V + R$$

monatomic: f=3; diatomic: f=5; polyatomic: f=6

•Change in entropy: $$\Delta S = \int_i^f \frac{dQ}{T}$$

1) Ideal gas: $$\Delta S = S_f - S_i = nR\ln\frac{V_f}{V_i} + nC_V \ln\frac{T_f}{T_i}$$

+Some special cases:

+ T = constant: $$\Delta S = nR\ln\frac{V_f}{V_i}$$

or $$\Delta S = \frac{Q}{T} = \frac{W}{T}$$

+ V = constant: $$\Delta S = nC_V \ln\frac{T_f}{T_i}$$

2) Liquid, solid:

+Cooling or heating: $$\Delta S = \int_{T_1}^{T_2}\frac{dQ}{T} = \int_{T_1}^{T_2}\frac{cmdT}{T} = cm\ln\frac{T_2}{T_1}$$

+Phase change: $$\Delta S = \frac{Lm}{T}$$

L is heat of vaporization or heat of fusion