

Review

• Work done by the gas:

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

$$pV = nRT$$

+3 special cases:

p = constant (isobaric):

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

V = constant (isochoric):

$$W = 0$$

T = constant (isothermal):

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

•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	$Q = 0$	$\Delta E_{\text{int}} = -W$
Constant volume	$W = 0$	$\Delta E_{\text{int}} = Q$
Closed cycle	$\Delta E_{\text{int}} = 0$	$Q = W$
Free expansion	$Q = W = 0$	$\Delta E_{\text{int}} = 0$

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

•Work done by the gas:

-Expansion: $W > 0$

-Compression: $W < 0$

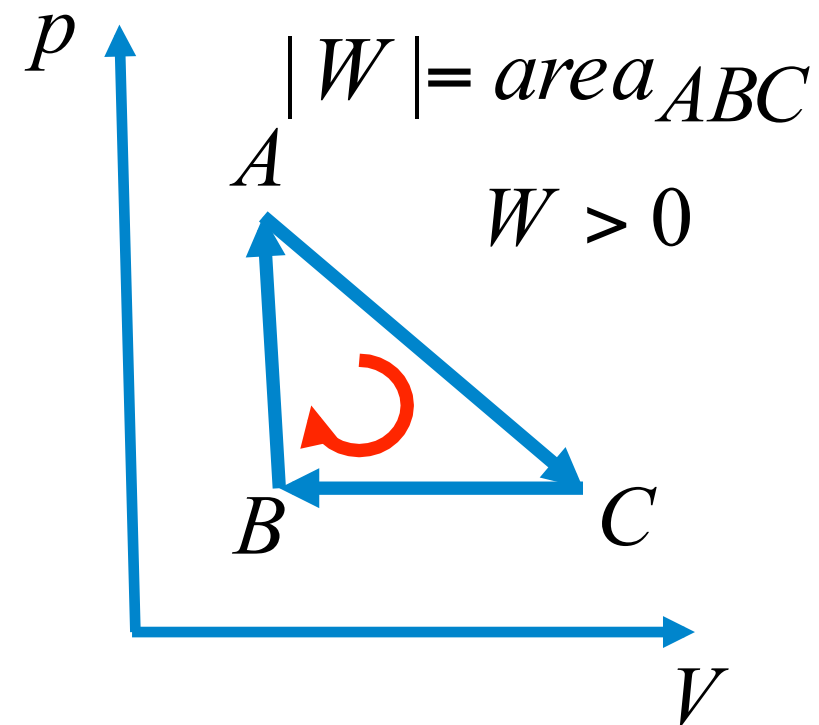
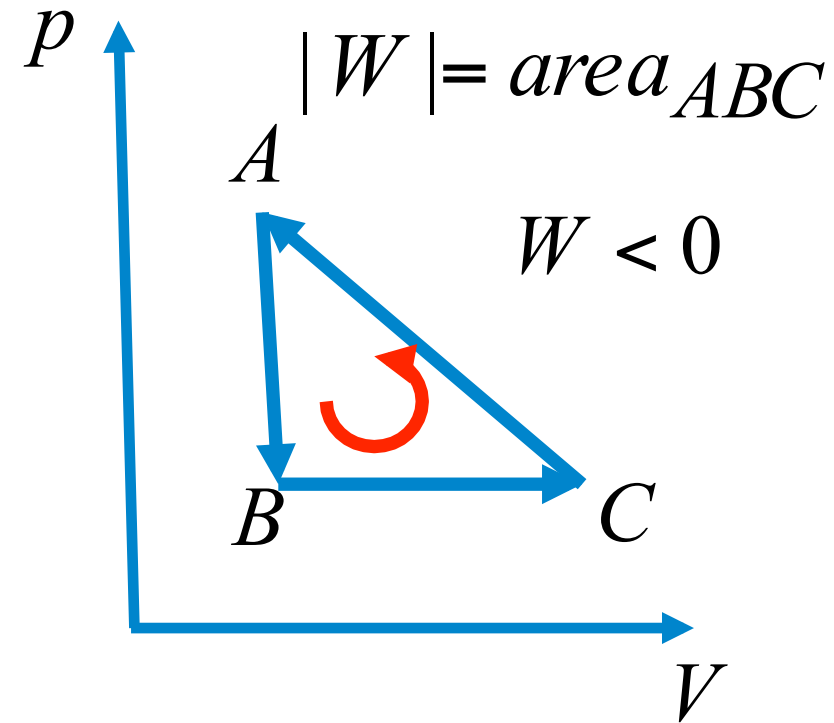
•Energy transferred as heat Q :

-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:

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

•Translational Kinetic Energy per Molecule:

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

•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:

$$Q = nC_p \Delta T$$

$$\text{with } C_p = C_V + R$$

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

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

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