Thermodynamic Processes

A thermodynamic process can be one of two types reversible or irreversible.

Reversible Process

- A process that can be taken through each intermediate state from final to initial

Examples

isothermal	$T_0 = T_f$	$\Delta E_{int} = 0$
isobaric	$P_0 = P_f$	
isometric	$V_0 = V_f$	$W = 0$
adiabatic	$Q = 0$	

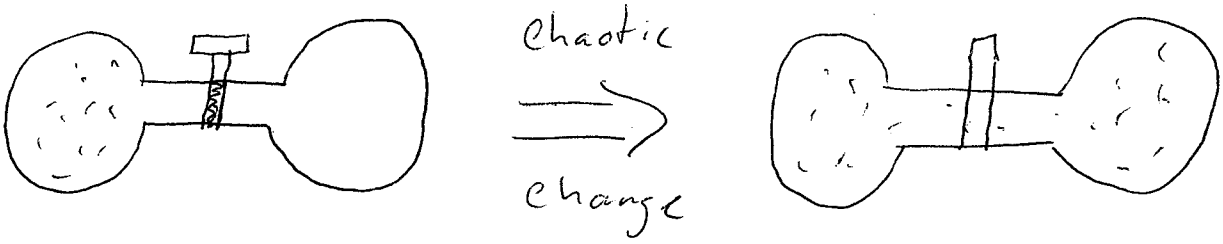
Irreversible Process

- A process that can not be taken back through all intermediate states from final to initial.

* the states are not known because the state changes were chaotic.

Example

Free expansion of a gas



Entropy (S)

- State variable that is used to:

1) measure the disorder of the system
2) measure/define the ability of the system to do useful work
3) Indicate the direction of natural events

#2 Relates the quality of heat to the temperature of the heat reservoir.

+ High quality heat energy comes from high temp. reservoir

Change in Entropy (ΔS)

$$\Delta S = S_f - S_i = \int_i^f \frac{dQ}{T}$$

special cases

- For an isothermal process

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

- For a process that <u>minimally</u> changes Temperature

↓

means

ΔT is small compared to T_f and T_i

$$\Delta S \sim \frac{Q}{T_{avg}}$$

ΔS for a reversible process

$$dE_{int} = dQ - dW$$

$$dW = P\,dV$$

$$dE_{int} = n C_V\, dT$$

$$n C_V\, dT = dQ - P\,dV$$

$$P = \frac{nRT}{V}$$

$$n C_V\, dT = dQ - nRT\frac{dV}{V}$$

$$dQ = n C_V\, dT - nRT\frac{dV}{V}$$

divide by T

$$\frac{dQ}{T} = n C_V \frac{dT}{T} - nR\frac{dV}{V}$$

$$\Delta S = \int \frac{dQ}{T} = n C_V \int \frac{dT}{T} - nR\int \frac{dV}{V}$$

$$= n C_V \ln\left(\frac{T_f}{T_i}\right) - nR \ln\left(\frac{V_f}{V_i}\right)$$

$\Delta S_{reversible} = \Delta S_{irreversible}$

* Entropy, like P, V, T depend only on initial and final state

- Even though information about intermediate states is lost initial and final information is available, so any process from a to b will produce the same ΔS.

Second Law of Thermodynamics

- Entropy of a closed system will always increase or at best remain constant

$\Delta S \geq 0$ for a closed system and natural process.

Alternate ways to view second law

* heat flows from high temp. to low temp.

* heat can't be completely used for mechanical work