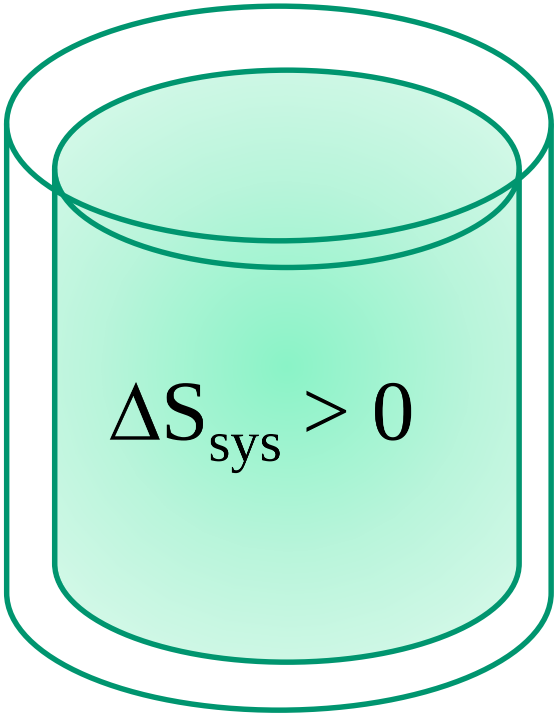
An isolated system requires ΔS > 0

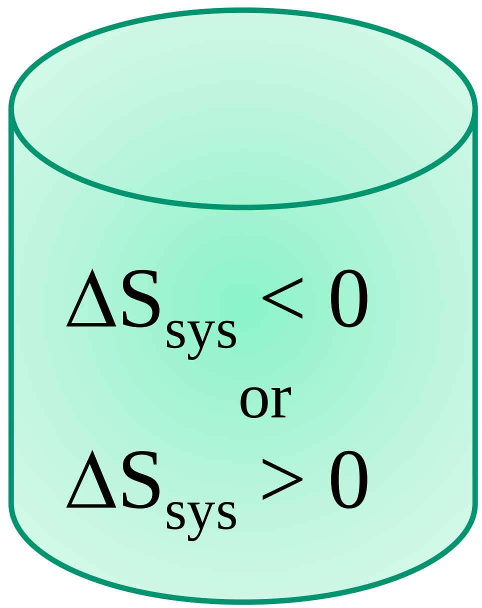


Isolated system:
Entropy increases for any spontaneous process

System and surroundings both play in role in the entropy

$$\Delta S_{sys} + \Delta S_{surr} > 0$$

$$\Delta S_{surr} > 0$$



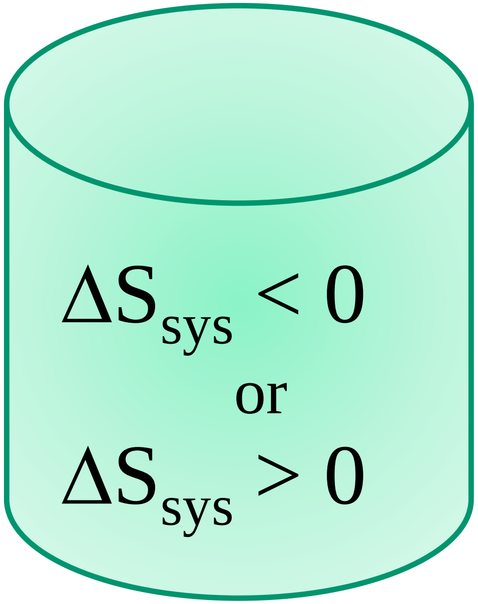
If the system is not isolated, then the entropy can have either sign for the System as long as the surroundings can compensate.

Closed system in contact with surroundings:
Entropy increases for any spontaneous process

We derive one function that includes both sys and surr

$$\Delta S_{sys} + \Delta H_{surr}/T > 0$$

$\Delta H_{surr}/T > 0$

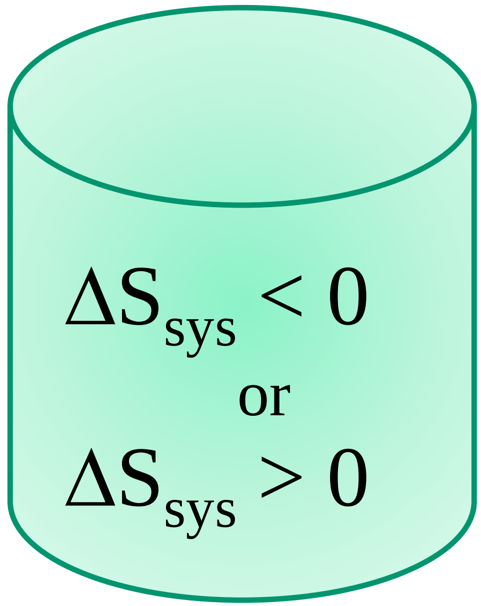


However, if we now turn to a case where the entropy change in the surroundings compensates for a change in the system, we can include the heat flow from surr to sys.

We derive one function that includes both sys and surr

$$\Delta S_{sys} - \Delta H_{sys}/T > 0$$

$$-\Delta H_{sys}/T > 0$$

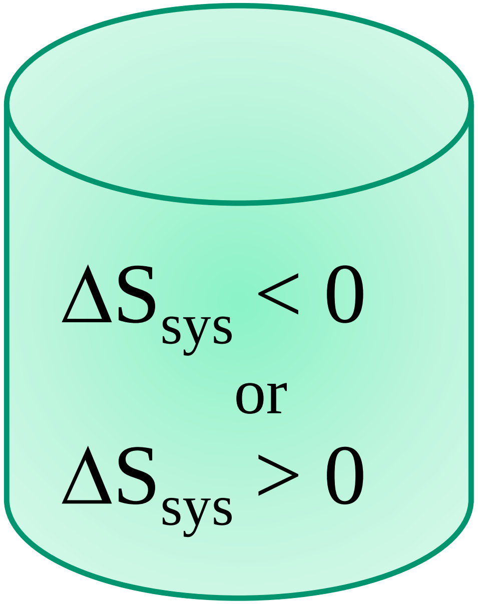


The heat flow to or from the system must opposite to that of the surroundings. Hence, there must be a minus sign In front of the enthalpy term.

We derive one function that includes both sys and surr

$$\Delta H_{sys} - T\Delta S_{sys} < 0$$

$$-\Delta H_{sys}/T > 0$$

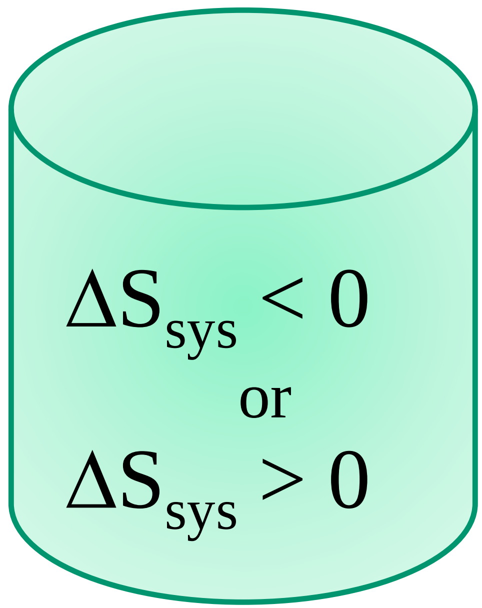


Here we have expressed the total change of system and Surroundings in terms of quantities that relate to the System. Hence, ΔH_{sys} -$T\Delta S_{sys}$ constitutes a new state function

We derive one function that includes both sys and surr

$\Delta G_{sys} < 0$

$-\Delta H_{sys}/T > 0$



Note the sign change when we multiplied by –T.
Here we have written the new state function explicitly
as the free energy change, ΔG, which is defined for the system.

Definition of Gibbs Free Energy

Reactions will proceed in the direction written if $\Delta G < 0$.
G decreases as shown in the figure below until G is constant.
At equilibrium, $\Delta G = 0$.

$$\Delta G = \Delta G^o + RT \ln Q$$

where Q is the reaction quotient. Q changes as the Reaction proceeds. Finally, at equilibrium Q = K. Therefore,

$$\Delta G^o = -RT \ln K$$