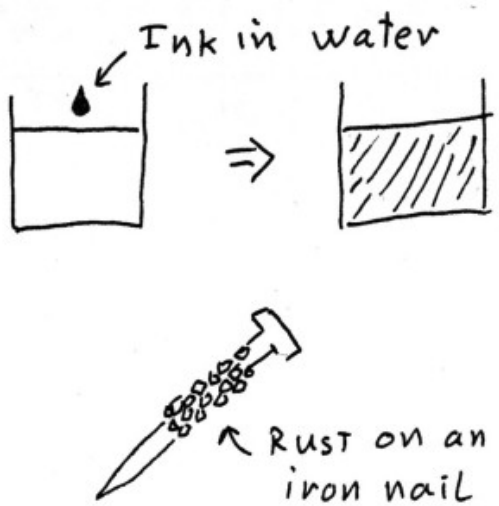
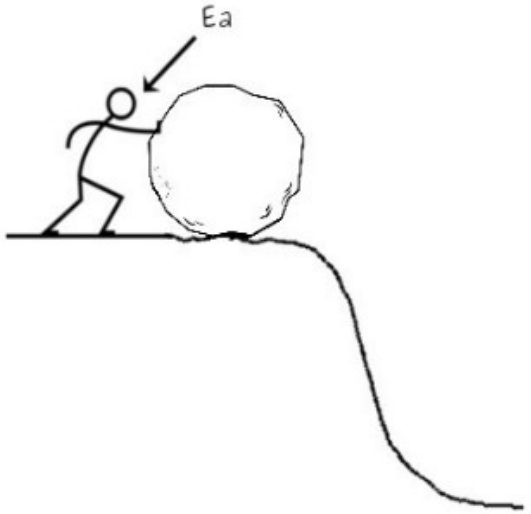
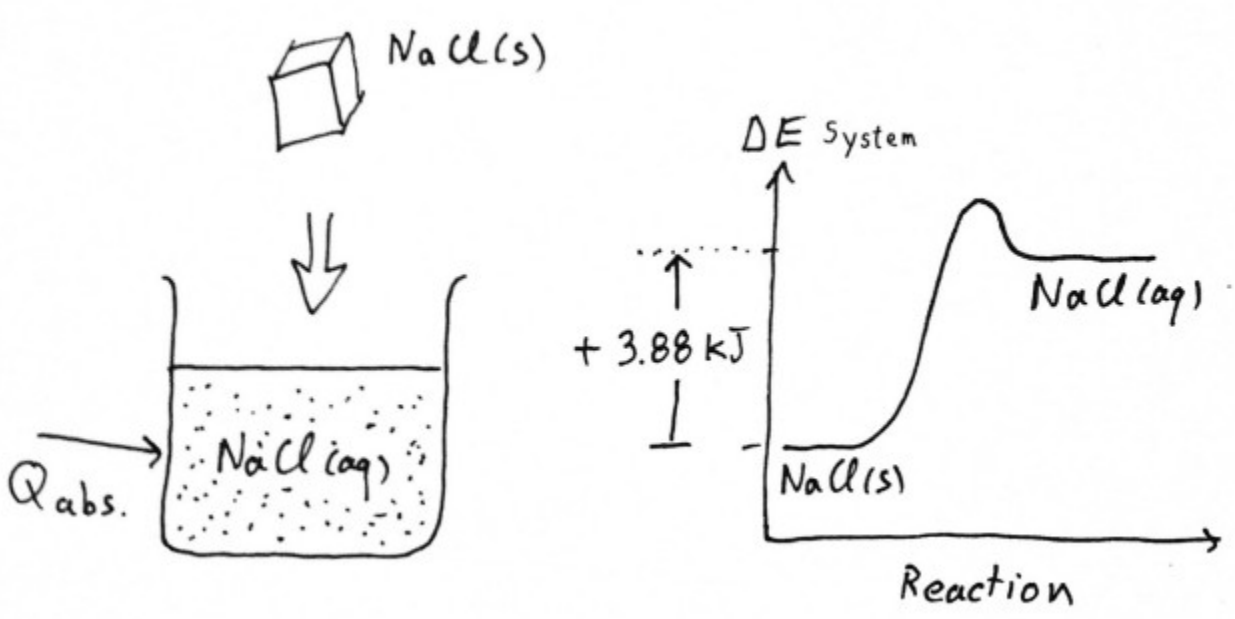
Spontaneous process

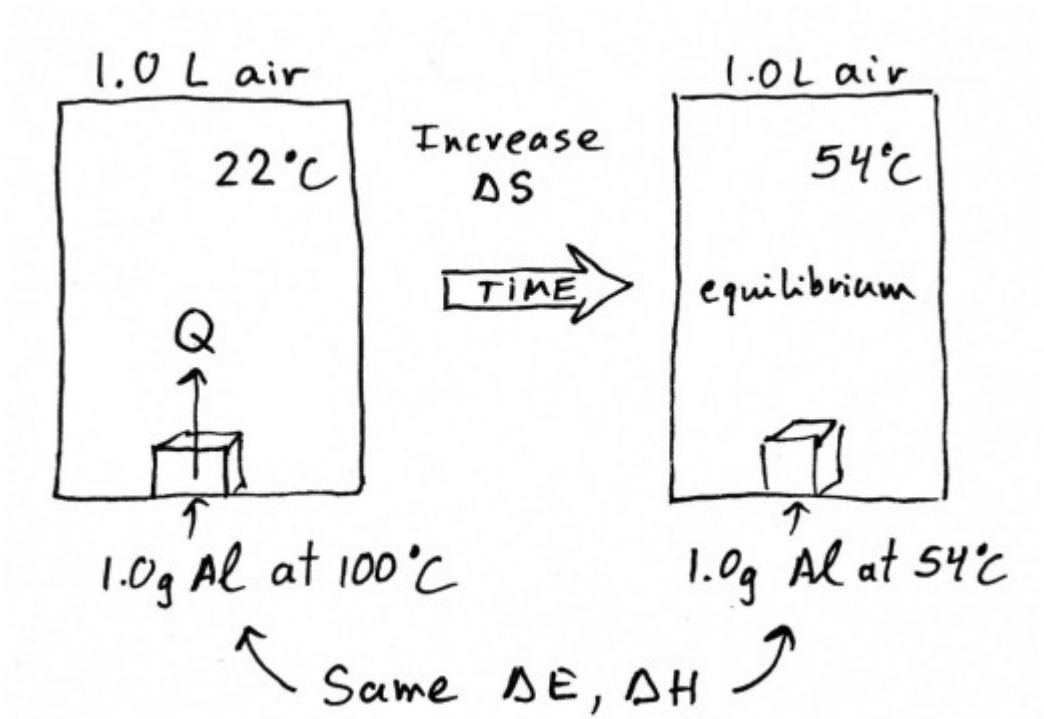
Example of spontaneous process / reaction






NaCl(s)
NaCl(aq)
Q abs.
ΔE System
+ 3.88 kJ
NaCl(aq)
NaCl(s)
Reaction

$$\Delta S = \frac{Q_{\text{reversible}}}{T} \qquad \text{units} = \text{J/K}$$



A process is spontaneous when both the system and its surrounding contribute to increase the total entropy. It is called the "entropy of the universe".

$\Delta S_{\text{universe}} = \Delta S_{\text{system}} + \Delta S_{\text{surrounding}}$

Entropy is the measure of the number of ways energy is distributed in a system

The Boltzmann description of entropy

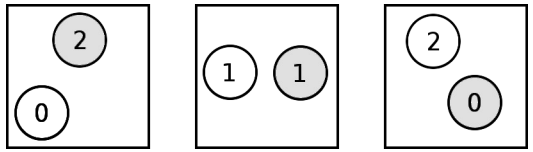
$$\mathbf{S = k \ln W}$$

k = Boltzmann constant (1.38×10^{-23} J/K) which is R/N_A

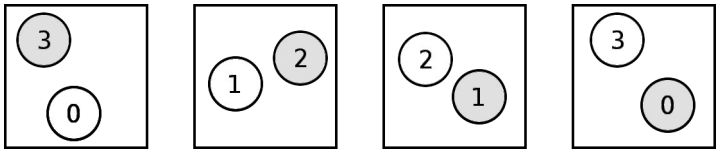
W = number of possible micro-state of a system.

Adding heat to a system increases its entropy

2 J of energy

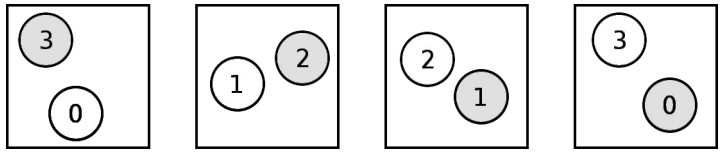


+ 1 joule of energy to the system

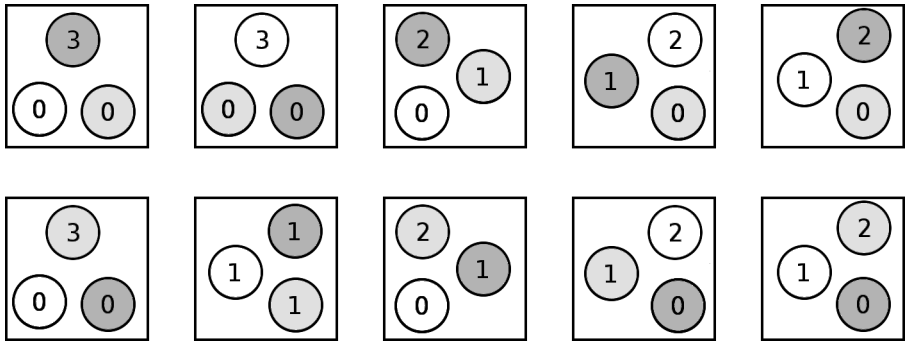


Adding matter (more particles) to a system increases the entropy

3 J of energy to the system

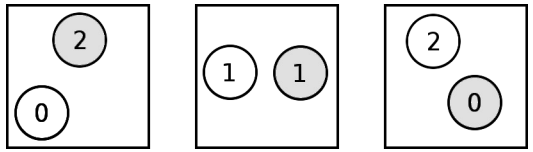


+ 1 particle added to the system

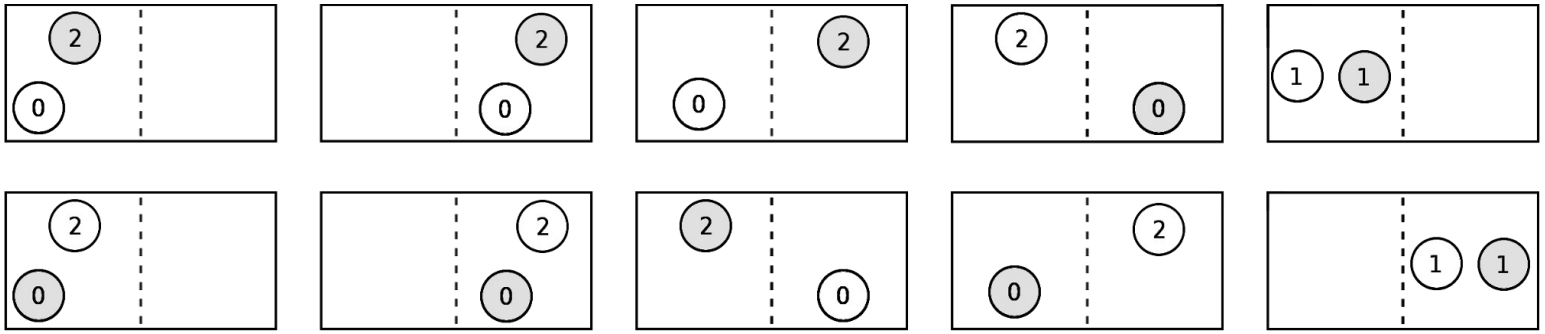


Increasing the size of a system increase the entropy

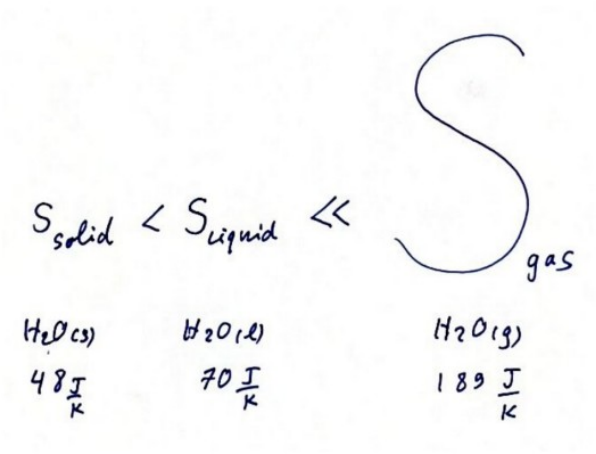
2 J of energy



adding more freedom of position



More space = more entropy.



More complex molecule = more entropy

Molecule (gas phase)	S° ($J.K^{-1}.mol^{-1}$)
H – H	131
O = O	205
O = S = O	248
SF_6	292
S_8	431

Change of entropy of a chemical reaction

System	ΔS_{system}	comment
$H_2O(\ell) \longrightarrow H_2O(s)$		
$KCl(s) \longrightarrow K^+(aq) + Cl^-(aq)$		
$2H^+(aq) + CO_3^{2-}(aq) \longrightarrow CO_2(g) + H_2O(\ell)$		
$S_8(s) + 8O_2(g) \longrightarrow 8SO_2(g)$		
$2CO(g) \rightleftharpoons CO_2(g) + C(s)$		