# Chemical Kinetics - Rates of Chemical Reactions



Corrosion and explosions are good examples of how fast or how slow a chemical reaction can occur.

**Experiment: the jumping tin**

**Revision exercise**

Chemical reactions are always associated with energy conversion: energy is either absorbed or released. You probably all know how this is usually displayed in a diagram. Please draw and name the two of them.

## Chemical reactions are dynamic

The **activation energy** determines directly the rate of reaction. At a constant amount of energy (e.g. at room temperature) the following rule applies: the higher the activation energy a given reaction requires, the slower the reaction.

The required amount of activation energy is hereby determined by the reaction pathway.

## Prerequisites for a chemical reaction

For particles to undergo a chemical reaction with each other, they have to get in contact first. However, such an encounter does not always lead to a reaction but depends on the following:

1. The energy of the involved particles has to be big enough for the reaction. This is the activation energy.
2. The particles have to collide in the right orientation.

On molecular level, there are two possibilities to accelerate a reaction: either the **number of collisions** is increased, or the **number of effective collisions. “**Effective” thereby means that the collision leads to a chemical reaction.

Exercise: On which of the above possibilities do the following measures have an impact:

* Increasing the concentration of a reactant
* Increasing the temperature
* Changing the reaction pathway

## 

## The reaction rate

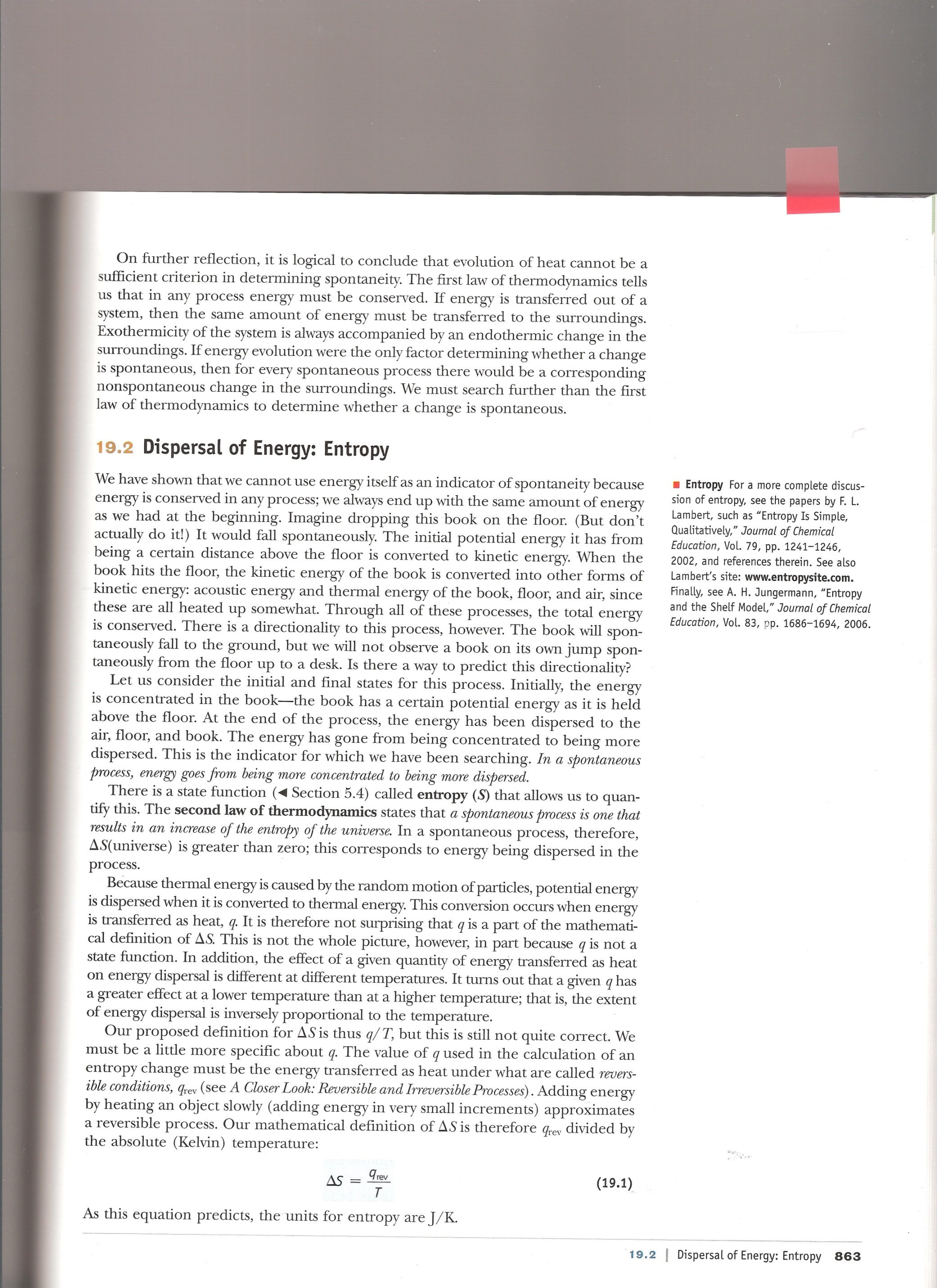
**Definition**: The reaction rate “v” is the change of the concentration of a reactant or product per unit of time. A positive number means that reactants are consumed and products produced.

The following factors do have an impact on the reaction rate:

## Experiment: decolourisation of benzal green

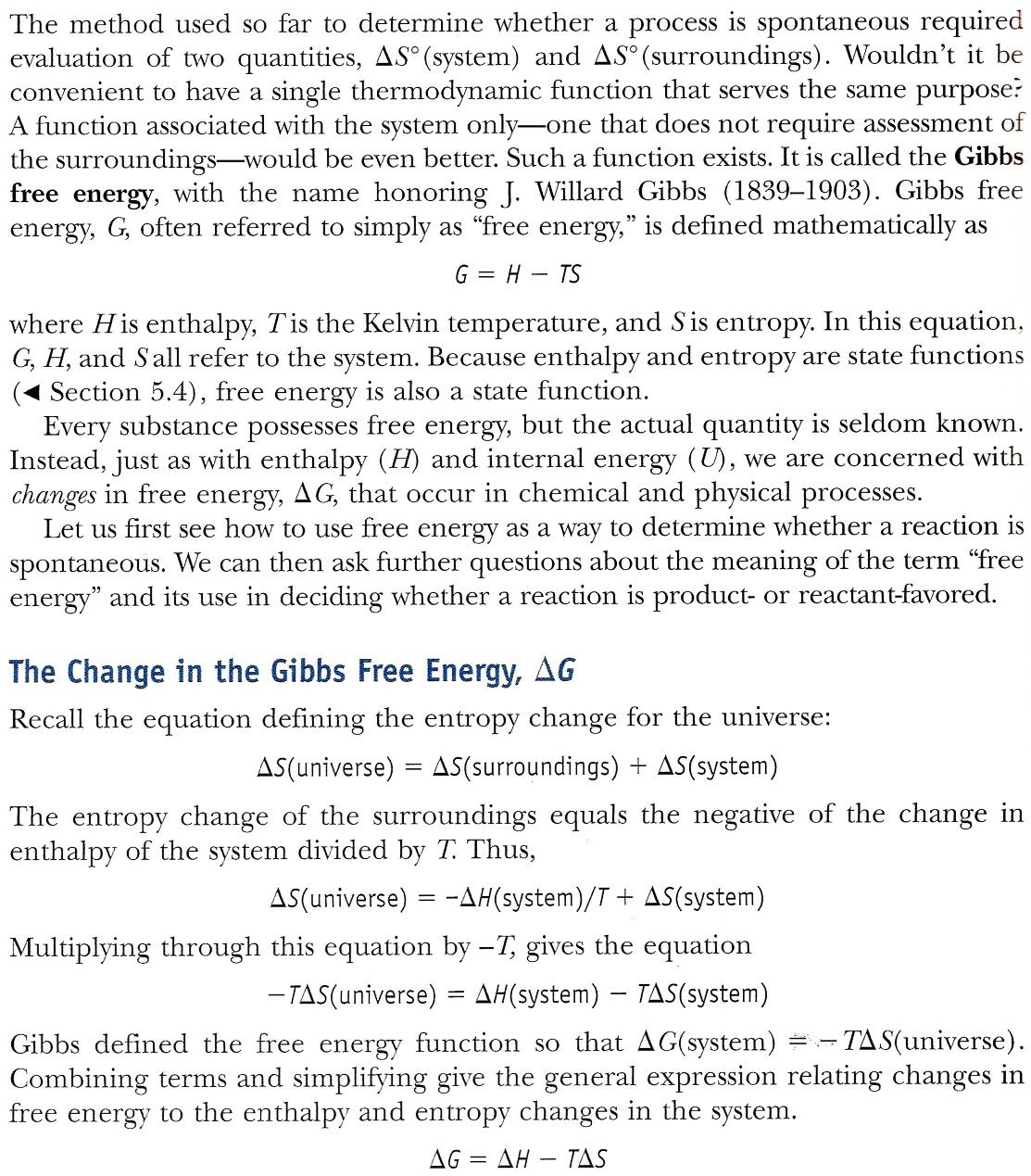
The dye benzal green is decolourised by sodium hydroxide solution. As discussed above the rate of this reaction depends on several factors.

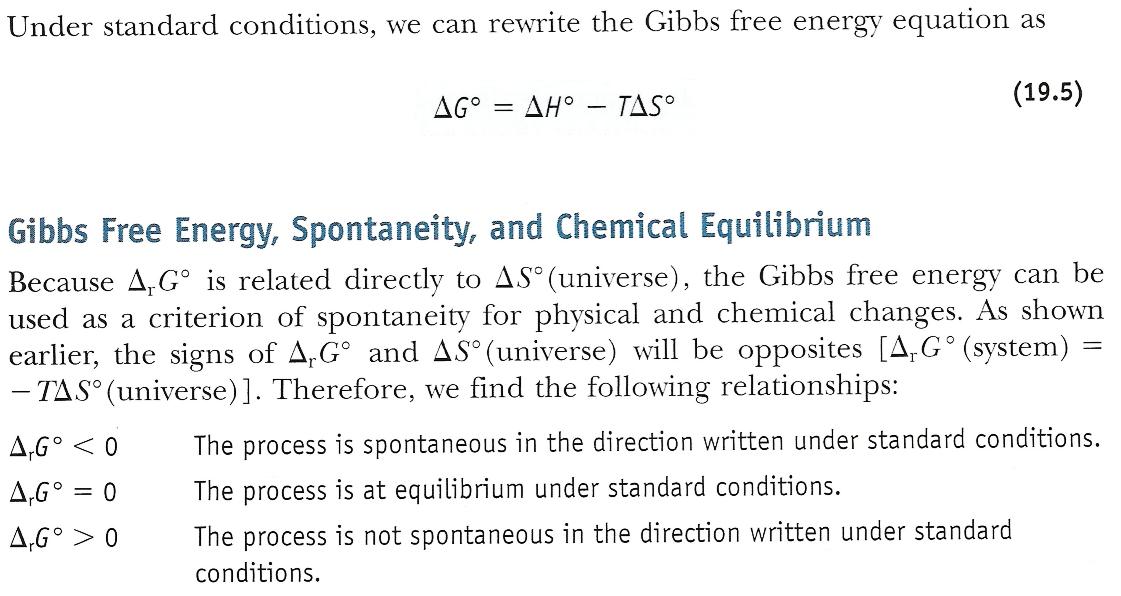
## Entropy: Measuring Dispersal of Energy



*From: “Chemistry and Chemical Reactivity” by John C. Kotz et al.*

## Gibbs Free Energy





*From: “Chemistry and Chemical Reactivity” by John C. Kotz et al.*

**Exercise:** What is the meaning of a negative ΔH, ΔS or ΔG?

## Conservation of Gibbs Free Energy



*From: “Chemistry – The Molecular Science” by Moore, Stanitski, Jurs*

***Nota bene:***

* The Gibbs free energy change provides a way of predicting whether a reaction will be **product-favoured** or **reactant-favoured.**
* ΔG represents the maximum useful work that can be done by a product-favoured system on its surroundings under conditions of constant temperature and pressure.

## Maxwell-Boltzmann Distribution

The moving particles in a gas or liquid do not all travel with the same velocity. Some are moving very fast and others much slower. The faster they move the more kinetic energy they possess. The distribution of kinetic energy is shown by a Maxwell-Boltzmann curve.

If only a small fraction of the reactants possess the energy needed for this reaction, a chemical reaction is slow

“Temperature“ therefore represents the average kinetic energy of all particles. The actual energy of an individual particle can vary considerably.

number

of  
particles

energy

activation energy

**Exercise**

1. What is the influence of the activation energy on a reaction?
2. At a temperature of 10°C a chemical reaction runs at a certain rate of reaction. How much faster would the reaction run if we heat to 100°C? As a rule of thumb we can assume that increasing the temperature by 10°C leads to a doubling of the reaction rate.