Basic knowledge

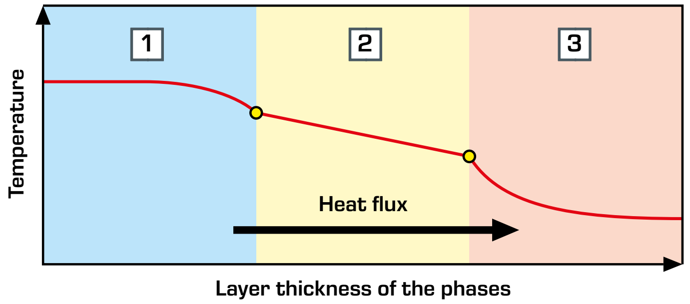
# Mass transfer

Mass transfer is one of various basic processes. These are, for example, drying processes, absorptions and adsorptions.

Substance systems or mixtures strive for the lowest possible energetic state. This is also referred to as the driving gradient. For a saline solution, for example, this means that the dissolved salt ions are distributed evenly. After some time, the same concentration will be measurable at every place.

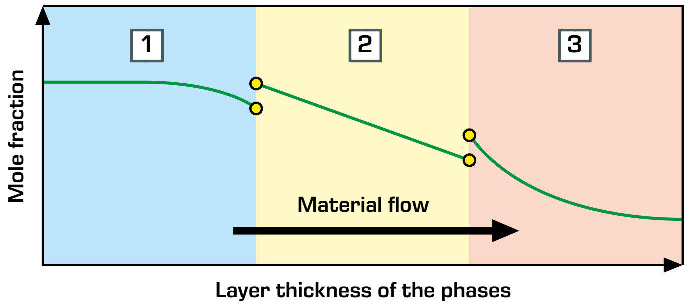
**Mass transfer** can be studied from the perspective of several mass transfer processes, such as diffusion or convective mass transfer, and is referred to as **overall mass transfer**.

Mass transfer is described with the individual mass transfer processes in a similar way to heat transfer processes. The two diagrams show the profiles of temperature and mole fraction and the respective transfer processes for plane phases.




Ideal heat transfer with three plane phases:

**1**, **3** heat transfer, **2** heat conduction




Mass transfer with three plane phases:

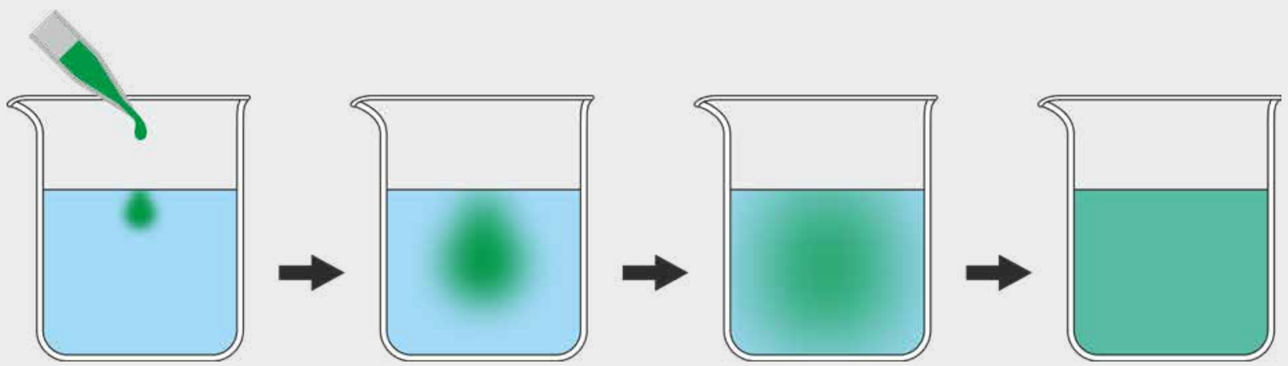
**1**, **3** mass transfer, **2** diffusion

## Diffusion

Diffusion is a physical process in which atoms or molecules migrate within a gas, a solution or even a solid. Diffusion is a **mass transfer process** based on molecular motion and is a way of reaching the lowest energy state. In general, diffusion requires a local difference in particle number density, which acts as the driving gradient. Diffusion processes end when an equilibrium of all particle number densities is reached. In solutions this usually takes several hours, whereas in gases it often takes only a few seconds.

The calculation is based on diffusion coefficients, which must be determined for the substances involved. The diffusion coefficient describes the mobility of a substance within another substance or mixture of substances. In the case of a saline solution, for example, it is the mobility of the salt ions within the water.

Diffusion can also be affected by temperature and pressure. The dependence on temperature is usually part of the calculation equation. Pressure is mentioned as additional information to check the validity of the calculation equation for the specific application.



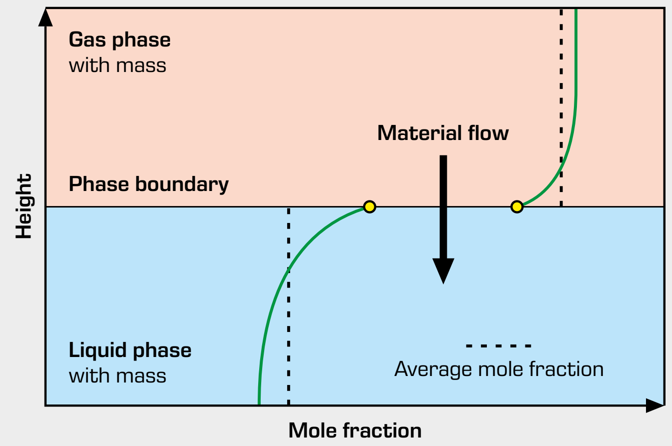
## Overall mass transfer

A task with mass transfer usually involves several mass transfer sections to be studied. The transfer process through all sections is referred to as **overall mass transfer**. The individual mass transfer processes are diffusion and mass transfer. These can also occur several times within one task.

**Example with dual mass transfer**

A gas phase is located above a liquid phase. Both phases are flowing. A substance is present in the gas phase that is soluble in the liquid phase. If the lowest energy state has not yet been reached, the system attempts to reach it. In this case, there is mass transfer of the substance from the gas phase into the liquid phase. In the gas phase mass transfer takes place towards the phase boundary and in the liquid phase mass transfer takes place away from the phase boundary. The mole fractions adjust until equilibrium is reached. The mass flow is calculated using the mass transfer coefficients and the driving gradient, which is formed from the difference of the mole fractions at the phase boundary and the average value within the phase.

One special characteristic of mass transfer is that the solubility of a substance is different in other substances. This means that the concentrations at the phase boundaries are different.




## Convective mass transfer

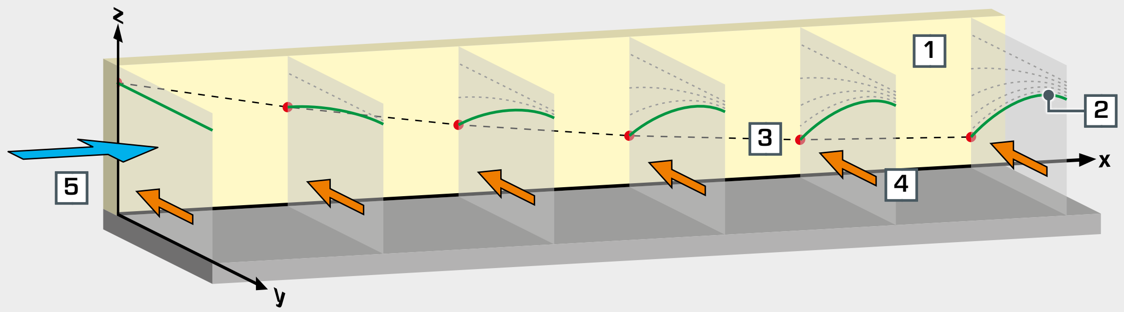
Convective mass transfer is a mass transfer process that takes place when a flow occurs simultaneously. The flow leads to a significantly better mass transfer, so that further equations have been determined for the design. The decisive factors for mass transfer are:

- flow condition (laminar or turbulent)
- degree of flow formation
- degree of profile formation of the mole fractions

Depending on the conditions, the Sherwood number together with the valid **Sherwood function** is used to calculate the mass transfer coefficient.

**Example**

A liquid phase containing a substance flows along a membrane. The substance is absorbed by the membrane. In the start-up of the profile formation, the mole fraction is constant and then decreases. Since the substance is absorbed by the membrane, the mole fraction sinks more directly at the membrane than further in the flow. The resulting profile of the mole fraction, transverse to the direction of flow, represents a further mass transfer resistance. This is taken into account by the mass transfer coefficient to be calculated in the overall consideration, the overall mass transfer.




**x** distance in direction of flow, **y** distance from the membrane, **z** mole fraction

**1** membrane, **2** mole fraction as a function of distance from the membrane (y),
**3** mole fraction in the immediate vicinity of the membrane (y = 0), **4** mass flow towards the membrane, **5** flow