

Wärme- und Stoffübertragung: Lernpfad Stoffübertragung

Nomenklatur

Subskript:

| | |
|----------|----------------------------------|
| adv | Advection |
| diff | Diffusion |
| conv | Convektion |
| i | Component-specific partial share |
| v | Vapor |
| ∞ | Environment |
| tot | Total |
| w | Water |
| O | Free Surface (Interface) |
| l | Liquid |
| v | Vaporisation |

Superskript:

| | |
|----|---|
| " | Area-related |
| "" | Volume-related |
| • | Time derivative (heat flow, mass flow, enthalpy flow, etc.) |

Symbole

| | | |
|--------------|--------------------------------------|--------------------------|
| m | Mass | [kg] |
| M | Molar mass | [kg/kmol] |
| n | Molar quantity | [kmol] |
| ρ_i | Partial density | [kg/m ³] |
| ρ | Total density | [kg/m ³] |
| C | Molar concentration | [kmol/m ³] |
| ψ | Mole fraction | [–] |
| ξ | Mass fraction | [–] |
| p_i | Partial pressure | [N/m ²] |
| V | Volume | [kg/m ³] |
| \dot{n} | Mass flux | [kmol/s m ²] |
| \dot{j} | Diffusion mass flux | [kg/s] |
| \dot{m} | Mass flow | [kg/s] |
| D | Diffusion coefficient | [m ² /s] |
| ν | Kinematic viscosity | [m ² /s] |
| λ | Heat conductivity | [W/m K] |
| c_p | Specific heat capacity | [J/kg K] |
| H_i | Henry-coefficient | [–] |
| u | Velocity | [m/s] |
| α | Convective heat transfer coefficient | [W/m ² K] |
| Δh_v | Evaporation enthalpy | [kJ/mol] |
| g | Mass transfer coefficient | [kg/m ² s] |

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Dimensionslose Kennzahl

| | | |
|----|-----------------|-----|
| Re | Reynolds number | [–] |
| Pr | Prandtl number | [–] |
| Nu | Nusselt number | [–] |
| Sh | Sherwood number | [–] |
| Sc | Schmidt number | [–] |

V 01: Introduction to mass transfer

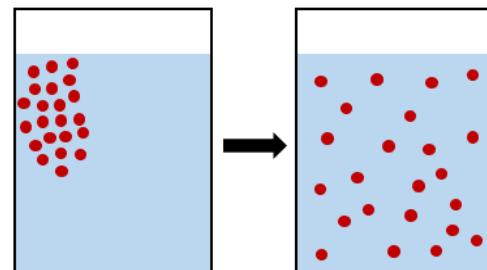
Learning goals:

- Understand the basics of mass diffusion
- Understand diffusion in gaseous binary mixture
- Learn about Fick's law
- Learn to draw the concentration profile of one-dimensional equimolar diffusion in binary gas mixtures at rest



Comprehension questions:

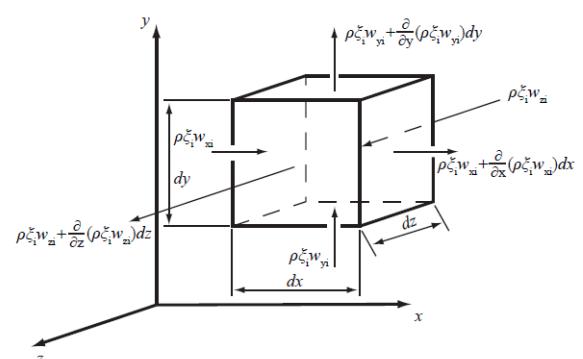
- What is the meaning of Dalton's Law?
- What is the meaning of Fick's Law?
- What does equimolar diffusion mean?
- What is the relationship between molar flux and diffusive mass flux?



V 02: Derivation of the conservation equation of material diffusion and analogy to heat transfer

Learning goals:

- Understanding of the necessary steps to develop the conservation equation
- Knowledge of the common features of heat, mass, and momentum transfer



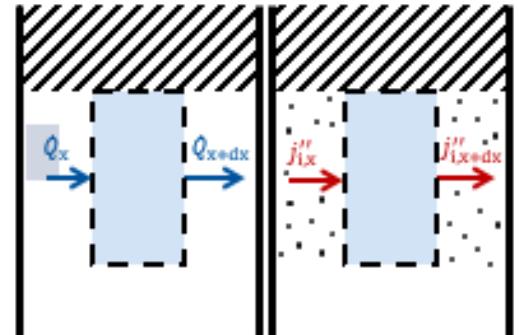
Comprehension questions:

- What is the analogy of the diffusion coefficient in heat transfer and momentum transport?

V 03: Example for analogy: Transient 1-D

Learning goals:

- Review of the solution of the one-dimensional heat conduction problem
- Understand the steps to solve the one-dimensional diffusion problem
- Understand to apply Heat Conduction “knowledge” to Diffusion problems



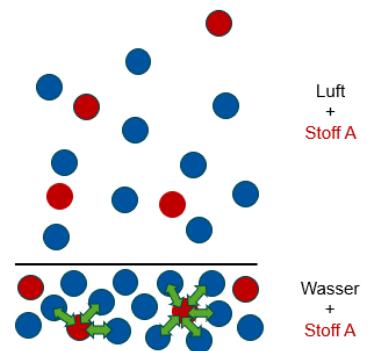
Comprehension questions:

- Which initial and boundary conditions are chosen when solving the one-dimensional transient diffusion problem?
- For what kind of problems can the Heisler diagrams be used? Which boundary conditions must be fulfilled?

V 04: Diffusion Phase Equilibrium

Learning goals:

- Describing the equilibrium between two phases, liquid/gas or liquid/liquid
- Consequences for the concentration course



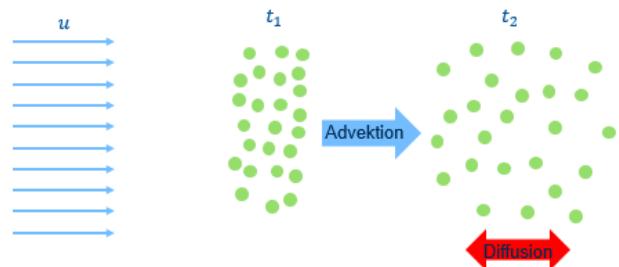
Comprehension questions:

- Which quantities determine the ratio of the mass concentration at a phase interface between liquid and gas phase?
- Why do the mass concentrations at the interface correspond to the equilibrium state even in the transient case?

V 05: Advective Mass Transport

Learning goals:

- Differentiation between diffusive and advective mass transport
- Understand the concept of mass average velocity and component velocity
- Learn the relevant dimensionless numbers and the analogy to heat transfer



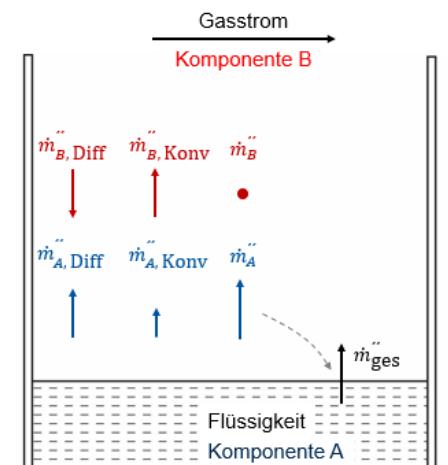
Comprehension questions:

- What is the name of the driving potential of diffusion and advective mass transfer?
- Which mass transfer dimensionless number can be considered as an analogue to the Prandtl number in heat transfer?
- Why is the sum of all diffusion flows equal to zero?

V 06: Evaporation at a liquid surface (Stefan-Strom)

Learning goals:

- Understanding the particularities of mass transfer on a liquid semi-permeable surface
- Understand and be able to explain the occurrence and important boundary conditions of the Stefan flow



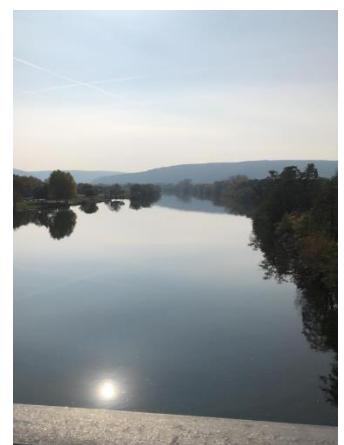
Comprehension questions:

- What causes the additional convection? What does it compensate for?
- Which parameter influences the amplification of the evaporation mass flow by convection in a significant way?

V 07: Example Evaporation Lake

Considerations:

- Does mass transfer limit the problem?
Mass flow = Transport coefficient * Driving potential
- Does heat transport limit the problem?
Heat flow = heat transfer coefficient * driving potential
Mass flow = heat flow / evaporation enthalpy



Comprehension questions:

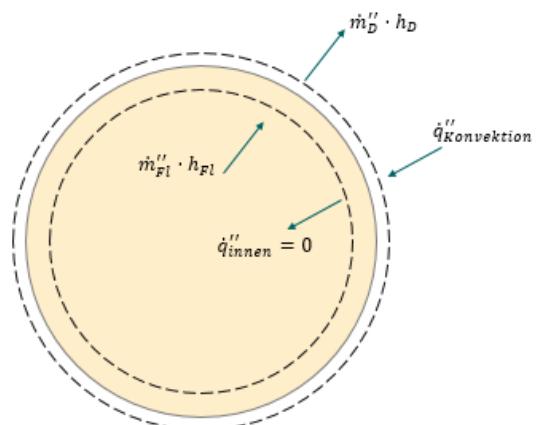
- How are mass fractions calculated?
- Under what conditions does the Lewis' law apply?
- How is the mass transfer coefficient calculated using Lewis' law?
- How is the mass of evaporating water determined?

$$\xi_{H_2O,i} = \frac{1}{\frac{1 - p_{H_2O}}{p_{H_2O}} \cdot \frac{M_{Luft}}{M_{H_2O}} + 1}$$

V 08: Evaporation of a droplet - Stefan flow

learning goals:

- Balance at the droplet
- Equilibrium temperature during evaporation of a droplet
- Mass flow of the evaporated fuel \dot{m}''
- Duration of complete evaporation of a droplet



Comprehension questions:

- Why is the determination of the surface temperature only possible iteratively?
- What are the considerations behind the estimation of the evaporation time of a droplet?

Why is the evaporation time of an exhaled droplet relatively large?