Study Guide for CM3120 Transport II
Module 3 Diffusion and Mass Transfer I
Morrison Spring 2021

Test subjects in this course are cumulative. Anything on a study guide from a prior exam may be the subject of a current exam.

In addition to Exam 1-2 topics, Exam 3 will cover the topics listed below.

To do well on the test, you should be able to do the following:

Material and system properties for mass transfer in mixtures

1. Define *diffusion* and give an example of diffusion taking place
2. Compare and contrast *diffusion, convection,* and *mass transfer*
3. Define *transport phenomena* and justify the inclusion of the three transport fields under this rubric (momentum, heat, mass of species A in a mixture)
4. Compare and contrast the choice to characterize mixture composition distributions based on *moles* (x_A, c_A) versus *mass* (ω_A, ρ_A)
5. Convert among the various ways to quantify the composition of a mixture $(\mathrm{x_A}, \mathrm{c_A}, \omega_\mathrm{A}, \rho_\mathrm{A})$
6. Determine vapor pressures from tables or empirical correlations; compare and contrast species A *vapor pressure* and species A *partial pressure*

Transport law: Fick's law of mass transfer (diffusion coefficient $\mathcal{D}_{AB}$)

7. Define the diffusion coefficient $\mathcal{D}_{AB}$ and explain how this quantity influences the mass-transfer behavior of mixtures.
8. Explain Fick's law of diffusion and where it is important in chemical engineering
9. Explain what material properties and system parameters affect the speed of transport of a species in a mixture
10. (stretch) In general terms, explain how non-Fickean diffusion may occur and how it differs from Fickean diffusion
11. (stretch) Define Brownian motion and explain what transport behavior is caused by Brownian motion
12. Calculate species A fluxes given concentration profiles, or the reverse
13. Interconvert among the various ways to write Fick's law

Microscopic species A mass balances

14. Compare and contrast the *conservation of species A equation* and *Fick's law of diffusion*
15. Interconvert species A fluxes in a mixture expressed in various units (mass and molar) and relative to various reference velocities
16. Explain the difference between a species' *bulk motion* and its *diffusion*
17. List the advantages/disadvantages in mass-transfer modeling of using balance equations based on the fluxes $\underline{j}_A$, $\underline{J}_A^*$, and $\underline{N}_A$

18. Explain the mass transfer modeling concepts of *source* and *sink*
19. (stretch) Explain how the continuum view is different when used for mixtures compared to when it is used for pure components
20. For a chosen mass flux scenario in a mixture, identify and justify reasonable modelling assumptions that will allow the concentration and species A flux fields to be determined
21. For a chosen 1D mass flux scenario in a mixture, calculate the species A concentration field. You must be able to indicate your assumptions and to show how you arrive at your answer from the principles discussed in the course

Boundary conditions (mass transfer in mixtures; Part I diffusion)

22. Identify appropriate concentration and mass flux boundary conditions for a species-A-transport scenario described
23. In detailed mathematical form identify appropriate concentration/concentration gradient and mass-flux boundary conditions for a species-A-transport scenario described

Concentration and mass flux profiles. If provided with a one-dimensional or two-dimensional concentration profile (also called a concentration distribution or the concentration field),

24. Sketch the concentration profile
25. Identify the driving force for species A mass transfer in a species-A-transport scenario described
26. Determine mass transfer engineering quantities of interest (concentrations at specific positions, molecular velocities, fluxes, evaporation rate $\dot{\mathcal{M}}$)

Using classical mass-transfer solutions (Part I Diffusion coefficients $\mathcal{D}_{AB}$)

27. Calculate local species velocities for species moving through stagnant layers, in equimolar counter diffusion, and with fast reaction at a surface
28. Determine engineering quantities of interest with the 1D rectangular film model (no reaction present)
29. Determine engineering quantities of interest with the 1D radial film model (no reaction present)
30. Determine engineering quantities of interest with a film model (with reaction present)
31. Explain what it means for a heterogenous reaction rate to be *diffusion-limited* or *mass-transfer limited*

References:

- Christie J. Geankoplis, Transport Processes and Unit Operations, 4th Edition, Prentice Hall, New York (2003).