

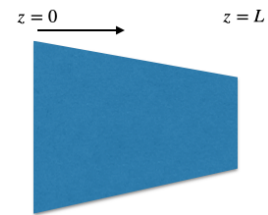
Name:
SCIPER:

Mid-term Exam
ChE 402: Diffusion and Mass Transfer

- Write your name and SCIPER number clearly on each page of your answer sheet (A4 sheets provided by us).
- Make assumptions if something is not clear. However, you must write down your assumption.
- Return this page with your answer sheets.
- There are several questions which ask for explanations. Limit your answers to 4-5 sentences for each explanation.

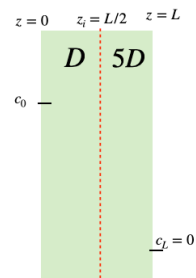
1) In the class, we discussed that in some cases $D = \frac{\Gamma a^2}{2}$, while in other cases, $D = \frac{\Gamma a^2}{4}$, and $D = \frac{\Gamma a^2}{6}$. Can you explain as to in which cases does D takes these value. Also explain why? **(6 points)**

2) A gas is diffusing from left to the right $z = 0$ to $z = L$ in a thin film with a variable cross-section. You are interested in calculating the concentration profile in this thin film.

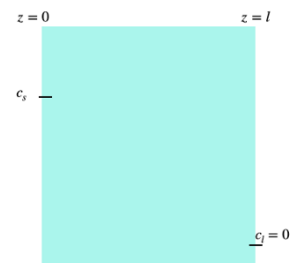


- a) What would be your system for mass balance and why? **(2 points)**
- b) How would you select as a volumetric element for mass balance and why? **(2 points)**

3) In the following composite thin film example, draw concentration profile, supported by calculation? **(9 points)**



4) A gas is diffusing from left to right in a block of polymeric film ($z = 0$ to $z = l$). Initially, for $t < 0$, concentration of the gas everywhere in the polymer is zero. At time $t = 0$, you suddenly raise the concentration of gas from 0 to c_s at $z = 0$. Here, $l = 100 \text{ cm}$. $D = 0.01 \text{ cm}^2/\text{s}$.



- a) Calculate the flux at $z = 0$ at time $t = 0$. **(4 points)**
- b) Calculate the ratio of fluxes (at $z = 0$ and at $z = 1 \text{ cm}$) at time $t = 1 \text{ s}$. **(10 points)**
- c) How would you calculate the total amount of gas that diffused inside the polymer film for a given time, let's say between $t = 0 \text{ s}$ and $t = 10 \text{ s}$. We do not want a numerical answer but an explanation in 4-5 sentences. **(10 points)**

5) When we use molar average velocity of gases for two gases (1 and 2), we often write $n = cv$, where c is total concentration and v is molar average velocity. Show as to why this equation holds? **(10 points)**

6) A train, carrying a container of water, is moving at a velocity of 100 km/h. The temperature of water is 25 °C, and its pressure is 1 bar. Calculate the convective flux of water. **(10 points)**

7) Find the ratio of the diffusion coefficients for small spherical particles in water, one with a diameter of 5 nm, and other with a diameter of 10 nm. **(10 points)**

8) A mixture of He and Ar gases is diffusing in a gas bottle at 1 bar and 25 °C. A diffusion coefficient of He in Ar is estimated to be 0.001 cm²/s.

- a) Calculate the diffusion coefficient of Ar in He. **(5 points)**
- b) Calculate the diffusion coefficient in part (a) again at 10 bar pressure. **(5 points)**
- c) Calculate the diffusion coefficient in part (a) again at 100 °C temperature. **(5 points)**

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9) A mixture of He and Ar gases is diffusing in various porous silica matrices. You managed to experimentally measure the flux of gas mixture and see the following profiles of flux as a function of pressure and as a function of diameter. Explain what is happening in each of these cases. (12 points)

