Quiz 3: Microreactors

Part 1: True-false

Circle T (true) or F (False)

1) **T** **F** At a given space-time in a microchannel, the Bodenstein number is larger for liquids than for gases.

2) **T** **F** The RTD in coiled channels may be narrower than in straight channels (at equal Re and internal diameter).

3) **T** **F** The RTD in fixed-bed reactors is broader than in empty tubes (at equal Re and internal diameter).

4) **T** **F** Radial diffusion in a microchannel leads to a decrease of the Bodenstein number.

5) **T** **F** The flow regime in passive micromixers is usually laminar.

6) **T** **F** Re_{cr} for zigzag channel micromixers is lower than for straight microchannels.

7) **T** **F** Re_{cr} applies to chaotic micromixers and indicates the value of Re above which vortices are formed.

8) **T** **F** The staggered herringbone is a multilamination micromixer

Part 2: Multiple choice

Choose the correct answer. Check only <u>one</u> box per question, as there is only one correct answer.

9) What is the name of the flow regime occurring in passive micromixers at high Reynolds numbers?

☐ engulfment ☐ stratified ☐ vortex

10) What is the approximate mixing time expected for liquids in a parallel lamination micromixer capable of generating 5-micron lamellae?

☐ 10 ms ☐ 1000 ms ☐ 0.1 ms

11) A reaction has to be carried out in droplets of organic phase in a segmented-flow microreactor. The carrier phase is water. Which channel wall material is recommended to minimize the RTD?

☐ Hydrophilic ☐ Hydrophobic ☐ The channel wall material has no impact on RTD

12) The approximate energetic efficiency of mixing of most passive micromixers is

☐ 10% ☐ 80% ☐ 3%

13) The key variable affecting the mixing time in a micro-device is

☐ Q ☐ ε ☐ u ☐ Δp

Part 3: Questions requiring written answers

14) Cite two possible reasons for the unexpectedly high experimental mixing times measured for micromixing devices with respect to the values predicted for simultaneous diffusion and shear elongation in the engulfment regime.

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15) Cite four key advantages of microreactors.

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16) Cite three types of passive micromixers (example: T-mixer).

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17) Give two reasons for unexpectedly low Bodenstein numbers that may be observed for multichannel micromixers as compared to the predictions using the Taylor-Aris model.

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18) Explain the sudden increase of Bo with Re above a certain critical value of Re for passive micromixers.

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19) Explain the reason for the high mass transfer coefficients observed in segmented flow

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20) The first stage of a serial lamination micromixer has a mixing time of 2 seconds for an initial characteristic lamellae dimension of 50 micrometers. Estimate the mixing time for a five-stage unit.

Solutions

1F, 2T, 3F, 4F, 5T, 6T, 7T, 8F, 9A, 10A, 11A, 12C, 13B

14) Concentration and flow fields don't match: energy is wasted to mix regions of pure A or pure B. Time is required to produce the "sandwich" structure.

15) Enhanced heat transfer, enhanced mass transfer, low mixing time, low holdup, narrow RTD

16) Y-mixer, staggered herringbone, superfocus, zigzag, meander

17) Uneven distribution, dampening at entrance and outlet

18) Formation of vortices➔radial mixing flattens the concentration profile

19) Internal circulation patterns in the plugs and slugs

20) $\frac{2}{4^{5-1}} = 7.8\ ms$