Exam

Exam on 14 December 2021

- Exam questions will appear here when the exam starts. If you cannot see the exam when the exam starts contact Tiia Viinikainen (@aalto.fi)
- Solutions and answers to the exam can be submitted to each question separately or as a one file containing solutions to all questions. In the latter case, mark clearly which question it is about!
- The exam ends at 19.00. Thus, make sure that all your submission files of the solutions have been submitted on time!
- Exam must be completed individually! Too similar answers and solutions can be regarded as fraud and cheat.
- Include some intermediate steps in your calculations – this may give you some points even though the final answer is not correct.
- You can answer to questions using pen and paper or computer. Handwritten material is scanned/photographed and collected to one file. Check that your handwriting is clear and writing is visible in all parts of the paper. Check that all pages are included in your submission.
- Remember to submit the (unique) collection of equations, too.

Question **1**

Flag question Marked out of 6.00 Complete

You are starting a new research of a catalytic reaction in a continuous flow reactor in isothermal conditions. You plan to determine the reaction mechanism and kinetic reaction rate equation for the reaction system but first you have to make sure that the information you get from your experiments is kinetic data, not affected by any other phenomena.

How would you study the following phenomena? What kind of experiments would you run in the system, i.e., which parameters or conditions would you change? What kind of information is obtained in these experiments? Answer with reasoning.

a) deactivation of the catalyst

b) external diffusion limitations in the system

c) internal diffusion limitations in the system

+ Bonus question: In which order would you study the abovementioned issues? Why?

Question **2**

Flag question Marked out of 6.00 Complete

In a catalytic reaction ($A + B_2 \rightarrow C + D$), the adsorption of reagent A is molecular whereas the adsorption of reagent B_2 is dissociative and non-competitive. Product C is formed directly to the gas-phase while product D is formed on a similar active site as reagent A is adsorbing. The rate-determining step is the adsorption of reagent A.

a) Suggest the catalytic steps for the reaction.

b) Derive the rate equation for the reaction.

+ Bonus question: Compare the catalytic steps and the derived rate equation. Comment on your findings.

Question **3**

Flag question Marked out of 6.00 Complete

An irreversible, elementary dimerization reaction (2 A → B) was studied in gas-phase at two different temperatures in a CSTR using 2.5 kg of catalyst. Conversion of A was measured with the fresh catalyst and after 100 h (see Table below). Calculate the activation energy for the catalyst decay, when it is known that the order of decay is 1. The flow rate of pure reagent A to the reactor was 50 mol/min at the reactor temperature and at atmospheric pressure.

T_1 = 150 °C			T_2 = 170 °C	
time (h)	X_A (%)		time (h)	X_A (%)
0	51.8		0	79.0
100	46.7		100	69.4

Question **4**

Flag question Marked out of 6.00 Complete

A liquid hydrocarbon is reacting in a first order reaction in a spinning basket reactor (CSTR) which is severely limited by internal diffusion. The reactant A is fed into the system at the rate of 6 mol/min with the concentration of 10 mol/dm^3. The reaction rate constant in diffusion-free conditions is known to be 5 dm^3/(kg$_{cat}$ min). The reactor system is packed with 100 g of porous spherical catalyst particles (d_p = 8 mm) and particle density of the catalyst is 3.2 kg/dm^3. Conversion of A is 4 %.

Calculate the effective diffusivity in the reaction conditions.

Question **5**

Flag question Marked out of 1.00 Complete

Drop here your collection of equations