
UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2008/2009

April/May 2009

EKC 533 – Industrial Catalysis and Reactor Engineering

Duration : 3 hours

Please ensure that this examination paper contains FIVE printed pages before you begin the examination.

Instruction: Answer **FOUR (4)** questions. Answer **ALL** questions.

Answer ALL questions.

1. [a] Two catalyst filled packed bed reactors are to be designed to process 100 mol/s of reactant A so as to produce product R. Feed gas enters at 2.49 MPa and 300 K, the allowable $T_{max} = 900$ K, $T_{min} = 300$ K, the product stream is required at 300 K, and the thermodynamics and kinetics of the exothermic reaction are given in Figure Q. 1.[a]. Prepare a sketch of your recommended design and show

[i] The flow arrangement selected: plug, recycle (give R value), or mixed (whenever $R > 5$). Do not consider injection of cold fluid between the stages.

[ii] Weight of catalyst needed in each stage.

[iii] Location and duty of heat exchangers.

[iv] Temperature of the flowing streams.

[16 marks]

[b] One of the greatest challenges in the design and operation of a large-scale catalytic process is the prevention of catalyst deactivation. The observed deactivation of a porous catalyst pellet depends on a number of factors. Briefly state these factors.

[3 marks]

[c] It is desired to characterize a Ni/Al₂O₃ catalyst for its heat stability. Name the technique used for this purpose and briefly state its procedure.

[2 marks]

[d] List the main steps of preparation a mixed oxide catalyst by precipitation method.

[2 marks]

[e] In the coming decade, the field of reactor design and modeling will see some remarkable paradigm shifts. Can you elaborate on these challenges.

[2 marks]

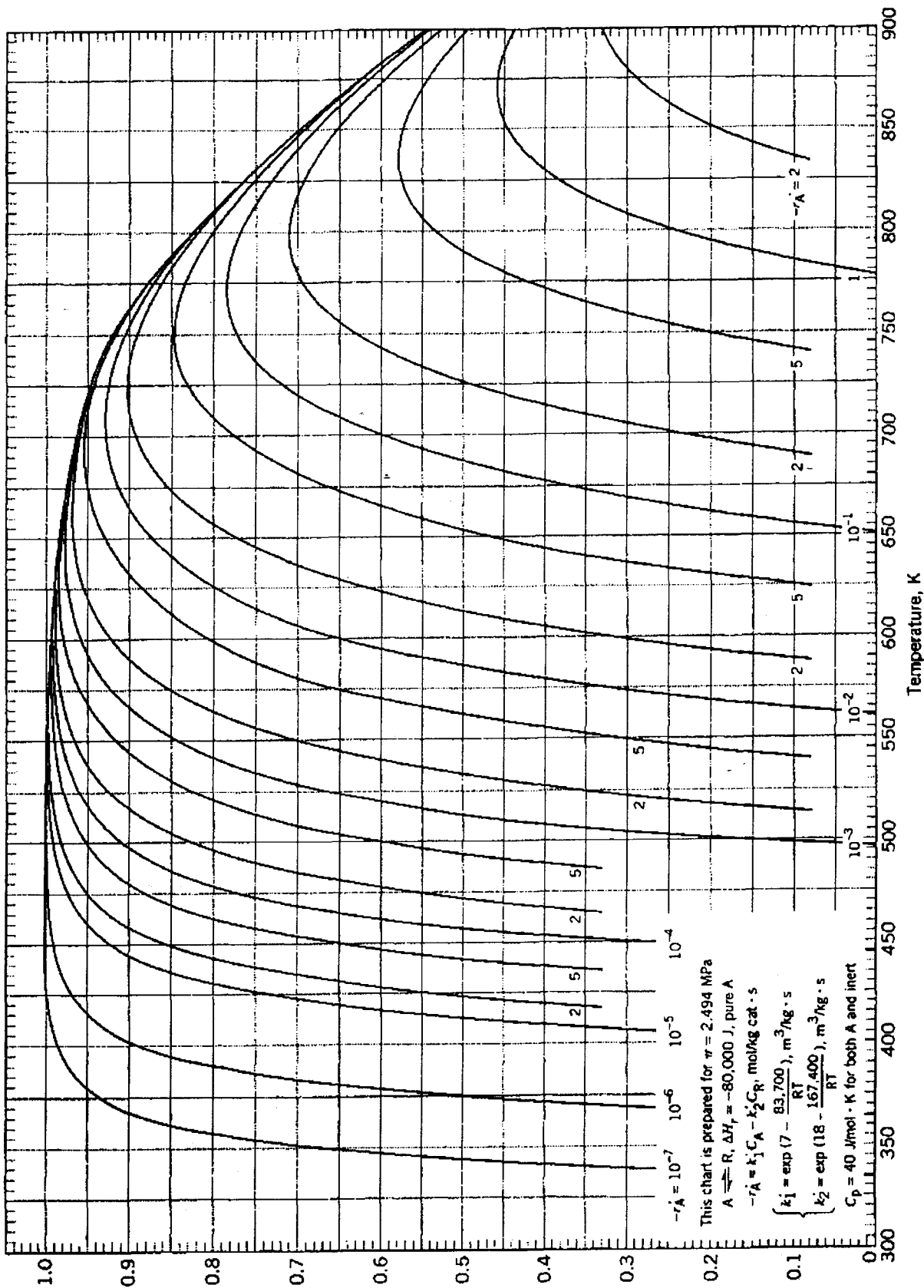


Figure Q. 1.[a]

2. [a] At 730 K, the isomerization of $A \rightarrow R$ proceeds on a slowly deactivation catalyst with a second-order rate:

$$-r'_A = k'C_A^2 a = 200C_A^2 a \quad [\text{mol A/h. g cat}]$$

Since reactant and product molecules are similar in structure, deactivation is caused by both A and R . With diffusional effects absent, the rate of deactivation is found to be:

$$-\frac{da}{dt} = k_d(C_A + C_R)a = 10(C_A + C_R)a \quad [\text{day}^{-1}]$$

It is planned to operate a packed bed reactor containing $W = 1$ metric ton of catalyst for 12 days using a steady feed of pure A , $F_{A0} = 5$ kmol/h at 730 K and 3 atm ($C_{A0} = 0.05$ mol/L).

- [i] What is the conversion at the start of the run?
- [ii] What is the conversion at the end of the run?
- [iii] What is the average conversion over the 12-day run?

[12 marks]

- [b] Despite our best efforts to prevent catalyst deactivation, the loss of catalytic activity in most processes is inevitable. When the activity has declined to a critical level, a choice must be made among some alternatives. State four of these alternatives and indicate the most preferred one.

[3 marks]

- [c] Fixed-bed reactors are the most common types of catalytic plant reactors.

- [i] What are the advantages of fixed-bed reactors?
- [ii] What are the disadvantages of fixed-bed reactors?
- [iii] Suggest methods to overcome the disadvantages of fixed-bed reactors.

[6 marks]

- [d] It is desired to minimize the pressure drop in a fixed-bed reactor. Two types of catalysts are available; spheres and monoliths. Briefly explain the advantage of each shape with respect to pressure drop.

[2 marks]

- [e] What is the difference between incipient wetness and wet impregnation method?

[2 marks]

...5/-

3. [a] Compare the process of CO_2 – Methane reforming and partial oxidation of methane for syngas production? Which one has more advantages? Justify your answer with necessary details.

[9 marks]

- [b] What are the poisonous oxygenates that affect iron catalyst in ammonia synthesis? How regeneration of iron catalyst is done?

[8 marks]

- [c] Why Platinum catalyst was used in nitric acid production? What is the role of Rhodium in the catalyst design?

[8 marks]

4. [a] Explain with a process flow diagram about hydrotreating of petroleum residuum.

[8 marks]

- [b] Compare the activity of platinum, vanadium, zeolite catalyst in NO_x conversion and validate the choice of best catalyst.

[8 marks]

- [c] What are the three common configurations of SCR catalysts? Draw a neat sketch for various SCR catalyst support geometries.

[9 marks]