

# CLL 371 Chemical Process Technology and Economics

Minor II: March 26, 2018

40 marks

Closed Book / Closed Notes

1 hour

- Please display your IDENTITY CARD prominently and keep it on your desk for inspection. Please do not write this exam unless you are carrying the i-card.
- No mobile phones or tablet PCs or laptops allowed during the exam. Only scientific calculators are allowed.
- There are 20 questions in this test. Each question is worth 2 marks.
- Please provide brief and to-the-point answers.

1. In a distillation tray tower, for a given bottom and distillate composition, under what conditions do we require minimum number of trays? Why is it not practical to work at this condition?

2. The slope of a q-line in a McCabe-Thiele diagram is 0. What is the thermal condition of the feed? When the feed stream enters the feed tray under this condition, does it immediately contribute to the liquid flow, vapour flow, or both?

3. "Transition from laminar (viscous) to turbulent (inertial) flow occurs around Reynolds number of 2100." Is this statement always true? Explain.

4. I have a countercurrent double pipe heat exchanger in which an exothermic reaction ( $A \rightarrow$  products, rate =  $-k C_A$ ) going on in the inside tube (heat of reaction is  $-\Delta H_r$ ). Water is flowing as a coolant in the outside pipe with an inlet temperature of  $t_{c.in}$ . The reactant fluid is entering at  $T_{h.in}$ . Flow rates of both fluids are known, their density, viscosity, and other properties (all independent of temperature) are known. Activation energy, frequency factor for the reaction are known. Can you give an estimate of the heat exchanger area that would be required, using the LMTD method? Make any assumptions that may be required.

5. Under what conditions is the LMTD based on end-temperatures of a double pipe heat exchanger the **same**, whether the hot and cold fluids are configured either in cold flow or counter-flow?

6. Concentration of carbon dioxide in a gas is 0.1 mol/litre and in a liquid is 1 mol/litre. If the liquid and the gas are brought in contact with each other:

- (a) There will be a net diffusion of carbon dioxide from the gas phase to the liquid phase;
- (b) There will be a net diffusion of carbon dioxide from the liquid phase to the gas phase;
- (c) There will be no net diffusion of carbon dioxide between the phases;
- (d) Cannot tell from the data.

Give your choice with a brief reasoning.

7. The drag coefficient for a bacterium moving in water at 1 mm/s, will be of the following order of magnitude (assumed the size of bacterium to be 1 micron and kinematic viscosity of water to be  $10^{-6} \text{ m}^2/\text{s}$ ):

(a) 24000

(b) 24

(c) 16

(d) 0.44

Give your choice with a brief reasoning.

8. In a counter-current double pipe heat exchanger, hot water enters the outer shell at 95 C and leaves at 40 C; while cold water enters the tube at 25 C. The cold water flow rate is twice the hot water flow rate. Specific heat can be assumed to be independent of temperature. What is the LMTD?
9. What is the difference between a fan, blower, pump and compressor? Given brief one-line specific differences.
10. Typically, will an exothermic reaction get rate limited or equilibrium limited as one increases the average reactor temperature? How about an endothermic reaction? Explain briefly.
11. What is the purpose of a crude desalting unit? Describe its operation with the help of a simple schematic sketch.
12. What is it necessary to do vacuum distillation of crude? Typically what kind of product streams are obtained out of vacuum distillation of crude.
13. What is the purpose of "MerOx" operation in a refinery? What kinds of MerOx are typically practiced?
14. What is meant by "EoR" in the petroleum industry? What is the purpose and typically in what ways is it done?
15. What is the density in g/cc of a crude oil which has an °API gravity of 20? What kind of crude is this (broad classification)? 73/100 .93
16. What is meant by connate water?
17. What is well logging? How is this data useful in the upstream petroleum industry?
18. What reactions are typically classified as naphtha platforming reactions? What is the purpose of platforming?
19. What is the "purpose" of the Maxwell's equations in thermodynamics? For solving what "real" problems are they actually used?
20. Under what conditions do we need to use a fluidized bed? Why can one not do all gas-solid reactions in a packed bed?