



NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF APPLIED CHEMISTRY

UNIT OPERATIONS

SCH 2208

Second Semester Examination Paper

May 2017

This examination paper consists of 5 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements:

Examiner's Name: Dr E Sanganyado

INSTRUCTIONS

1. Answer ALL questions from Section A and Any Three (3) questions from Section B.
2. Start each question on a fresh page.

MARK ALLOCATION

QUESTION	MARKS
SECTION A:	40
SECTION B: 6.	20
7.	20
8.	20
9.	20
TOTAL POSSIBLE MARKS	100

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Section A

Answer all questions.

1. 2000 kg of a 5% wt slurry of calcium hydroxide in water is to be prepared by diluting a 20% wt slurry. Calculate the quantities required. [5 marks]

2. Answer true or false on the following questions. Each sub question is worth **2 marks**.
 - a. Material balance calculations on processes with by-pass streams are different to those involving recycle.
 - b. Unsteady-state behavior of a process is important when considering the process start-up and shut-down.
 - c. In a steady-state process there is no accumulation of both mass and energy.
 - d. By definition, semi-batch and continuous systems are open systems.
 - e. Shaft work is the rate of work done by the fluid at the system outlet minus the rate of work done on the fluid at the system inlet.

3. Classify the following processes as batch, continuous, or semi-batch, and transient or steady-state. [10 marks]
 - a. A balloon is filled with air at a steady rate of 2 g/min.
 - b. A bottle of milk is taken from the refrigerator and left on the kitchen table.
 - c. Water is boiled in an open flask.
 - d. Carbon monoxide and steam are fed into a tubular reactor at a steady rate and react to form carbon dioxide and hydrogen. Products and unused reactants are withdrawn at the other end. The reactor contains air when the process is started up. The temperature of the reactor is constant, and the composition and flow rate of the entering reactant stream are also independent of time. Classify the process (i) initially and (ii) after a long period of time has elapsed.

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4. A young engineer recommended using an irreversible adsorption process to purify large amounts of gases.
- What is the advantage of using irreversible adsorption? [2 marks]
 - What is the problem with this suggestion? [5 marks]
5. A chemical plant wants to produce a highly-purified gas of purity above 97%. The chemical engineer recommended using the slipstream for stripping the gas product. However, additional studies showed that the slipstream is flammable.
- What type of adsorption would you recommend for the stripping process? And why? [6 marks]
 - What challenges is the engineer most likely to face in designing this type of adsorption equipment? [2 marks]

Section B

Answer only 3 questions.

6. The following questions examines your knowledge of material and energy balances.
- Material balances are the basis of process design. Therefore, a good understanding of material balance calculations is essential in process design. However, a process engineer is supposed to operate and maintain a chemical plant, in addition to process design. In what ways is understanding material balances critical in process operation and maintenance? [10 marks]
 - Material and energy balances are important in agriculture, particularly in pesticide application. Loss of pesticides following application to a tobacco field can lead to environmental pollution. However, a thorough understanding of energy and material balance can be used to minimize environmental pollution. With aid of diagram, calculations and examples, explain how you can use material and energy balances to reduce environmental pollution. [10 marks]

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7. In a review article on process intensification, Hannsjörg Freund and Kai Sundmacher argued, “When analyzing a typical chemical process, we can identify the level of individual apparatuses (process units). Such a process unit comprises one or more thermodynamic phases. At the process unit level, we can realize measures of process intensification by designing the individual process spaces and thus by controlling the local processes inside the process units.” From the numerous process intensification measures that can be identified at the process unit level, discuss 5 of the most important measures you could use to revamp the local process industry. [20 marks]

8. Show all your working.

a. An experiment on the growth rate of certain organisms requires an environment of humid air enriched in oxygen. Three input streams are fed into an evaporation chamber to produce an output stream with the desired composition.

A: Liquid water, fed at a rate of $20.0 \text{ cm}^3/\text{min}$

B: Air (21 mole% O_2 , the balance N_2)

C: Pure oxygen, with a molar flow rate one-fifth of the molar flow rate of stream B.

The output gas is analyzed and is found to contain 1.5 mole% water. Draw and label a flowchart of the process, and calculate all unknown stream variables. [10 marks]

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b. A continuous deodorizing system, involving a single stage steam stripping operation, is under consideration for the removal of taints from cream. If the taint component is present in the cream to the extent of 8ppm and if steam is to be passed through the contact stage in the proportions of 7.5kg steam to every 1kg cream, calculate the concentration of the taint in the leaving cream. The equilibrium concentration distribution of the taint has been found experimentally to be in the ratio of 1 in the cream, to 10 in the steam and it is assumed that equilibrium is reached in each stage.

[10 marks]

END OF QUESTION PAPER!!!!

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