

16-CHEM-A5, CHEMICAL PLANT DESIGN and ECONOMICS

NATIONAL EXAMS - DECEMBER 2018

3 hours duration

NOTES

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. The examination is a **CLOSED BOOK EXAM**. One aid sheet allowed written on both sides.
3. Candidates may use approved **Sharp/Casio** calculator.
4. **Five (5) questions** constitute a complete exam paper.
5. The questions are of equal value (**20 points each**).
6. Only the **first five questions** as they appear in the answer book(s) will be marked.
7. Clarity and organization of the answer are important. For questions that require calculations, please show all your steps.
8. State all assumptions clearly

Q1. The catalytic dehydrogenation of propane (C_3H_8) is carried out in a continuous packed-bed reactor. 1000 kg/hr of pure propane is preheated to a temperature of 670 °C before it passes into the reactor. The reactor effluent gas, which includes propane, propylene (C_3H_6), methane (CH_4) and hydrogen, is cooled from 800 °C to 110 °C and fed to an absorption tower, where the propane and propylene are dissolved in oil. The oil then goes to a stripping tower in which it is heated, releasing the dissolved gases. These dissolved gases are recompressed and sent to a distillation column in which the propane and propylene are separated. The propane stream is recycled back to join the feed to the reactor preheater. The product stream from the distillation column contains 98% propylene, and the recycle stream is 97% propane. The stripper oil is recycled to the absorption tower.

a) [8 points] Draw a flowsheet for the entire process. Label all feed, product, and connecting streams between units.

b) [12 points] Write clear statements of the overall objective of the process and the functions of each of the process units.

Q2. A process has been developed for a new product for which the market is uncertain. A plant to produce 50,000 tons/year requires an investment of $\$10 \times 10^6$, and the expected project life is 5 years. Fixed operating costs are expected to be $\$7.5 \times 10^5$ per year, and variable operating costs (excluding raw materials) is expected to be $\$40$ /ton of product. The stoichiometric raw materials costs are $\$80$ /ton of product. The yield of product per ton of raw material is 80%. Tax is paid in the same year as the relevant profit is made at a rate of 35%. Calculate the selling price of the product to give minimum acceptable discounted cash flowrate of return of 15% per year.

- Q3.** Pilot plants are complete, medium-scale processing units that contain all essential product-producing elements, including control. The conversion of laboratory data from the research group into plant design data is only one function of the pilot plant. After a new plant or process is designed, the pilot plant continues investigations of problems that require the elimination of the compromise acceptance of data. List and describe the top five important items to be considered in a pilot plant investigation.
- Q4.** List and describe the top six important technical factors to consider in the design of a full-size commercial plant.
- Q5.** The design of a full-size chemical plant must not only be technically satisfactory, but also must be economically satisfactory; the goal of the design is to secure a workable plant with maximum return on the necessary investment. List and describe the top four important economic factors to consider in the design of a full-size commercial plant.
- Q6.** A pharmaceutical plant manufacturing bulk drugs uses acetone for final purification of a product. After filtration, the wet cake is dried in a fluidized-bed dryer in which nitrogen is used as a drying medium. The off gases from the dryer is saturated nitrogen with vapor of water and acetone at near atmospheric pressure and 75-90 °C. Local pollution control authority requires that the emissions from the dryer must contain acetone below 200 ppm. Suggest a process scheme such that the final gas mixture meets the local pollution authority's requirement with reasons for selection of the scheme.