



INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR
Mid-Autumn Semester 2022-23

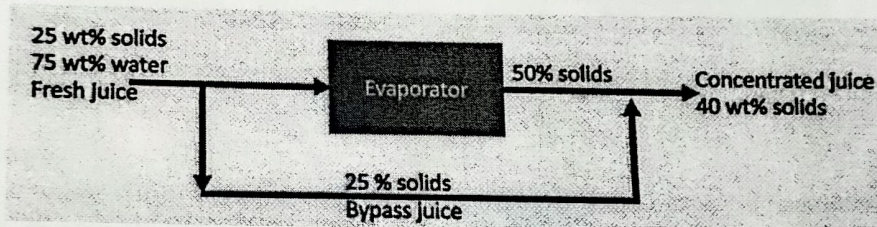
Date of Examination: 23/09/2022 Session FN Duration 2 hrs Full Marks: 30
Subject No.: CH21103 & CH21203 Subject: CHEMICAL PROCESS CALCULATIONS
Department/: CHEMICAL ENGINEERING

Specific charts, graph paper, log book etc., required:

Special Instructions (If any): Answer all questions. Assume, if necessary, clearly stating them. No queries will be entertained during the examination.

PART A

1. In the production of a bean oil, beans containing 13.0 wt% oil and 87.0% solids are ground and fed to a stirred tank (the extractor) along with a recycled stream of liquid n-hexane. The feed ratio is 3 kg hexane/kg beans. The ground beans are suspended in the liquid, and essentially all of the oil in the beans is extracted into the hexane. The extractor effluent passes to a filter. The filter cake contains 75.0 wt% bean solids and the balance bean oil and hexane, the latter two in the same ratio in which they emerge from the extractor. The filter cake is discarded and the liquid filtrate is fed to a heated evaporator in which the hexane is vaporized and the oil remains as a liquid. The oil is stored in drums and shipped. The hexane vapor is subsequently cooled and condensed, and the liquid hexane condensate is recycled to the extractor.
 - a) Draw and label a flowchart of the process, do the degree-of-freedom analysis, and write in an efficient order the equations you would solve to determine all unknown stream variables, circling the variables for which you would solve. (2+4+2)
 - b) Calculate the yield of bean oil product (kg oil/kg beans fed), the required fresh hexane feed (kg hexane/kg beans fed), and the recycle to fresh feed ratio (kg hexane recycled/kg fresh feed). (1+1+1)
2. Given below is a process flow chart to concentrate the solids present in fresh lime juice using an evaporator:



From the above flow chart, calculate:

- a) the percentage of fresh juice that is bypassing the evaporator. (2)
- b) the amount of concentrated juice produced in kg per 100 kg of fresh juice fed into the evaporator. (2)

PART B

3. Your answer should contain logic for choice of data

- (A) Find out the specific Enthalpy of water at $P = 10.0$ KPa and Sp. Volume = $10 \text{ m}^3/\text{kg}$. What is the temperature of water? (1.5+0.5)
 - (B) 1 Kg of steam at $P=2.5$ MPa and $T=1050^\circ\text{C}$ undergoes a process in a closed container so that the final pressure becomes 1.4 MPa. What is the final temperature of steam? (3)
 - (C) A closed vessel contains steam at 3.75 MPa in a 3:1 vapor - volume - to - liquid volume ratio. What is the steam quality? (2)
4. Draw the typical Phase diagram of water (T-P). Mark the invariant points on the graph. Please comment how the phase diagram of water is different from that of any other material. How do you justify the difference? From the graph comment on the condition under which sublimation is possible. Why it is not possible to liquefy a gas above critical temperature? (1+1+1+2+1+2)

