

NATIONAL INSTITUTE OF TECHNOLOGY HAMIRPUR  
(An Institute of National Importance under Ministry of HRD)  
Department of Chemical Engineering

CH-411 PROCESS PLANT DESIGN AND ECONOMICS  
END-SEMESTER EXAMINATION

Maximum Marks: 50 | Time: 3 hours

**Instructions:**

- Make suitable assumptions, if necessary, by clearly stating them.
- Marks will be deducted for omitting steps.
- Draw the figure wherever needed.
- **Answer against each question must be written in sequence and at the same place in the answer booklet.**
- Exchange of calculator, pen, pencil etc. are strictly not allowed.

**Q1. (10 Marks) [CO1, CO3]**

A concern has a total income of \$1 million/yr and all expenses except depreciation amount to \$600000/yr. At the start of the first year of the concern's operation, a composite amount of all depreciable items shows a value of \$850000 and overall service life is estimated to be 20 years. The total salvage value at the end of the service life is estimated to be \$50000. Thirty % of all profits before taxes must be paid out at income taxes. Determine the reduction in income tax charges for the first year of operation if the sum-of-the-years digits method were used for depreciation accounting instead of SLM.

**Q2. (10 Marks) [CO1, CO2, CO3, CO4]**

In a peanut processing plant 10 ton/h of miscella (15 wt% peanut oil in hexane) leaves at 35°C. As a process engineer you are asked to propose a processing scheme which can separate the hexane from the oil so that the final oil contains less than 0.01% hexane and such that the temperature never exceeds 80°C. Begin with what seems to be the most economical process 'distillation', start answering the following questions in sequence and come out with your proposal for processing scheme:

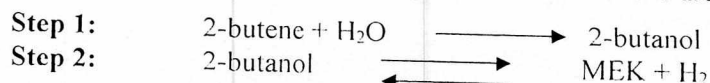
- What makes you so confident that distillation is plausible?
- The vapor pressure of hexane in a solution containing 0.01% hexane in peanut oil at 80°C is only 0.6 mm Hg. Normally, even vacuum distillation towers do not operate at pressure less than 100 mm Hg. How will you operate the distillation column at this lower pressure?
- How are you going to choose the tower pressure? Justify.
- For the sake of argument, fix the still pressure at 200 mm Hg and assume that the still can be designed. Will you face any other problem?
- Indeed this one of the plausible alternatives. Vapor liquid equilibrium calculations reveal that a flash of the hexane-peanut oil solution at 75°C and 1 atm will remove 85% of the hexane, and at 75°C and 300 mm Hg 98% of the hexane will be removed. Can you suggest some modification in the existing alternative to reduce the load on the distillation. Draw the flowsheet.

**Additional Information**

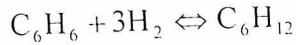
Mol. wt. of: Peanut Oil = 885.02, Hexane = 86.18, Vapor pressure of peanut oil is 0 mm Hg at 20°C, Dew point of hexane is 87°C at 151 mm Hg of pressure. Cooling water is available at 25°C.

**Q3. (10 Marks) [CO1, CO2, CO3]**

- In the given reaction system, assume the second reaction is reversible. The main product is 2-butanol which produces MEK as a by-product. The reactions are as follows:



- Discuss the decision for recycling or recovering the byproduct (i.e. MEK).
- b) Cyclohexane is produced by the following reaction.



Discuss the design guidelines with respect to decision making at level-3 corresponding to the use of excess amount of reactant.

**Q4. (10 Marks) [CO1, CO2, CO3, CO4]**

Consider a condensation process for recovering acetone from air-acetone stream (acetone = 10.3 mol/h and air = 687 mol/h). The air-acetone stream is available at ambient conditions (77°F and 1 atm). Two alternatives of condensation process are given below:

Alternative-1

The condensation process operates at 15 psia to recover 99.5% of acetone.

Alternative-2

The condensation process operates at 113°F to recover 99.5% of acetone.

- Propose a flowsheet for the acetone recovery process (for both alternatives).
- What temperature would be maintained in Alternative-1?
- What pressure would be required in Alternative-2?
- Describe the economic trade-offs involved in the design of the condensation process for both alternatives.

The coefficient values for acetone used in appropriate equation are  $A = 16.6513$ ,  $B = 2940.46$ ,  $C = -35.93$  (when vapor pressure and temperature are given in **mm Hg** and **K**, respectively).

**Q5. (10 Marks) [CO2, CO3]**

For the problem given with  $\Delta T_{min} = 10 \text{ }^\circ\text{C}$ , depending upon the units in a given problem, carry out the Energy Integration Analysis (Heat Exchanger Network Synthesis) using Pinch Technology by determining the following:

- Shifted temperature scales diagram with net heat in respective intervals.
- Cascade Diagram.
- Pinch Temperatures.
- T-H diagram.
- How does increase in approach temperature affects the utility requirement? Justify your answer using the T-H diagram.

Stream No.	Condition	$FC_p$ (kW/°C)	Source Temperature (°C)	Target Temperature (°C)
1	Hot	30	300	80
2	Hot	45	200	40
3	Cold	40	40	180
4	Cold	60	140	280

\*\*\*\*\*ALL THE BEST\*\*\*\*\*