# NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

## DEPARTMENT OF APPLIED CHEMISTRY

## END OF SECOND SEMESTER EXAMINATIONS - MAY 2002

## UNIT OPERATIONS - SCH 2208

## TIME - 3 HOURS

**INSTRUCTIONS TO CANDIDATES**

**Answer all questions in sections A and B. Answer ANY TWO questions from section C.**

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**SECTION A**

1. A fuel gas contains 6%$H_2$, 3%$CO_2$, 2%$O_2$, 28%CO and 61%$N_2$ is burned with 29% excess air. The combustion of CO is only 95% complete. For 100kgmol of fuel gas, calculate the moles of each component in the outlet stream. (10 marks)

2. Distinguish between constant rate period and falling rate period in drying. State any two advantages and disadvantages of drying. (6 marks)

3. (a) What is reflux ratio. How does the reflux ratio influence the number of plates in a distillation column. (5 marks)

   (b) Derive the operating and enriching section lines in distillation. (10 marks)

4. Water containing 6.8mg/litre of a steroid is extracted with initially pure methylene dichloride. The equilibrium constant for the steroid is 170 and the ratio of water to solvent is 82. What is the concentration in the organic phase after extraction.? What fraction of the steroid has been removed. (5 marks)

5. Explain in brief the operation of a rotary drier. (4 marks)

## SECTION B

6. A continuous countercurrent multistage system is to be used to leach oil from meal by benzene solvent. The process is to treat 2000kg/hr of inert solid meal (B) containing 800kg oil (A) and also 50kg benzene C. The inlet flow per hour of fresh solvent mixture contains 1310kg benzene and 20kg oil. Settling experiments similar to those in the actual extractor show that the solution retained depends upon the concentration of oil in the solution. The data are tabulated below as N kg inert solid B/kg solution and $y_A$ kg oil A/kg solution.

| N | 2.00 | 1.94 | 1.82 | 1.68 |
|---|---|---|---|---|
| $y_A$ | 0.00 | 0.20 | 0.40 | 0.60 |

Calculate the amounts and concentrations of the stream leaving the process and the number of stages required.

(20 marks)

## SECTION C

7. (a) Discuss any two ways in which the utilisation of steam can be improved in evaporation processes.

(8 marks)

(b) In order to concentrate 4000kg/hr of NaOH solution containing 1.0wt% to 2.0wt% solution, a single effect evaporator is being used with an area of 32.6m$^2$. the feed enters at 294.3K. Saturated steam at 383.2K. is used for heating and the pressure of the vapour space in the evaporator is at 101.325kPa. Calculate kg/h of steam used and the overall heat transfer coefficient.

The latent heat of vaporisations are:

For Steam = 2230kJ/k

For the vapour = 2309kJ/kg

(Assume no boiling point rise and Cp = 4.14kJ/kgK)

(12 marks)

8. (a) What are the five parameters that must be considered when choosing a solvent for liquid liquid extraction. (5 marks)

(b) With the aid of a diagram, derive the material balance equation over **n** stages of multiple extraction in countercurrent contact with immiscible solvents. (15 marks)

9. Calculate the drying time for a liquid 81% moisture (w.w.b.) which must be dried to 6% moisture (w.w.b.). Assume that critical and falling rate periods apply with a critical moisture content of 2kg/kg dry material and the following is known.

| | | |
|---|---|---|
| **LIQUID** | Density | $= 989 kg/m^3$ |
| | Particle diameter | $= 265 \times 10^{-6} m$ |
| | Latent heat of vaporisation | $= 2.39 \times 10^6 J/kg$ |
| | Thermal Conductivity | $= 0.0314$ W/mK |
| **AIR** | Incoming Temp (dry bulb) | $= 170^{\circ}C$ |
| | Wet bulb temp | $= 40^{\circ}C$ |
| | Exit air temp | $= 102.4^{\circ}C$ |
| **PRODUCT** | Density | $= 289 kg/m^3$ |
| | Exit temp | $= 52.1^{\circ}C$ |

(20marks)

***END OF QUESTION PAPER!!!***