NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE
END OF SECOND SEMESTER EXAMINATIONS – AUGUST 2009
UNIT OPERATIONS – SCH 2208
TIME: 3 HOURS

Instructions and notes to Candidates

1. There are two sections to this paper: A and B.
2. Answer **_all_** questions in Section A (40 marks).
3. Answer **_any three_** questions in Section B (60 marks).
4. Section A carries 5 questions while Section B carries 4 questions.
5. Show all your working steps logically.
6. Write legibly.
7. Start answers for each question on a fresh page.

SECTION A (40 Marks)

1. (a) What is a dimensionally inhomogeneous equation, give an example?

    (2 marks)

    (b) In the concentration of orange juice a fresh extracted and strained juice containing 7.08 wt % solids is fed to a vacuum evaporator. In the evaporator, water is removed and the solids content increased to 58 wt % solids. For 1000 kg/h entering, calculate the amounts of the outlet streams of concentrated juice and water.   (6 marks)

2. (a) What is the material balance of a steady state process?   (2 marks)

    (b) A wet solid is dried from 25 to 10 % moisture under constant drying conditions in 15 ks (4.17h). If the critical and the equilibrium moisture contents are 15 and 5 % respectively, how long will it take to dry the solid from 30 to 8 % under the same conditions?   (6 marks)

3. (a) For the system NH_3-water and only a vapour present, calculate the number of degrees of freedom. What variables can be fixed?   (3 marks)

    (b) 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)

4. (a) Steam jets are used to compress the vapour in a thermal vapour compression unit. State two disadvantages steam jets. (2 marks)

(b) Define the following terms:
(i) equilibrium moisture
(ii) free moisture
(iii) bound moisture (6 marks)

5. Ammonia is stripped from a dilute aqueous solution by countercurrent contact with air in a column containing seven sieve trays. The equilibrium relationship is $y_e = 0.8x_e$, and when the molar flow of Air is 1.5 times that of the solution, 90 % of the ammonia is removed.
(a) How many ideal stages does the column have, and what is the stage efficiency?
(b) What percentage removal would be obtained if the air rate were increased to 2.0 times the solution rate? (8 marks)

SECTION B (60 Marks)

Answer **_any three_** questions. All questions carry equal marks.

6. (a) Answer any two questions.
(i) Define:
1. Evaporator economy
2. Raoult's law

(ii) Define:
1. Boiling point elevation
2. Reflux splitter

(iii) Define:
1. HETP
2. Diffusion battery

(4 marks)

(b) With the aid of diagrams, using Webre's experiment, describe the effect of feed temperature on the economy and the evaporation in each effect for a forward feed triple effect evaporator (12 marks)

(c) Describe the effect of impurities on crystal formation, giving examples where possible. (4 marks)

7. (a) (i) What is the difference between pasteurization and sterilization?
(2 marks)

(ii) Discuss the process of freeze-drying. In your discussion include the principles, advantages and disadvantages and industrial application of freeze drying. (8 marks)

(b) (i) State two types of separation processes. (2 marks)

(ii) With the aid of a diagram describe how moving bed leaching process is carried out. (8 marks)

8. (a) (i) What is flash distillation? (3 marks)

(ii) When choosing solvents for extraction operations, certain qualities are required for this selection. Mention *any four* and explain them in brief.
(8 marks)

(b) Baker's yeast is to be grown in a continuous fermentation system using a fermenter volume of 20 m3 in which the flow residence time is 16 h. A 2% inoculum containing 1.2 % of yeast cells is included in the growth medium. This is then passed to the fermenter, in which the yeast grows with a steady doubling time of 2.9 h. The broth leaving the fermenter then passes to a continuous centrifuge which produces a yeast cream containing 7% of yeast, 97% of the total yeast in the broth. Calculate the rate of flow of the yeast cream and of the residual broth from the centrifuge. (9 marks)

9. (a) After precipitation and draining procedures, it is found that 100 kg of fresh casein curd has a liquid content of 66% and this liquid contains 4.5% of lactose. The curd is washed three times with 194 kg of fresh water each time. Calculate the residual lactose in the casein after drying. Also calculate the quantity of water that would have to be used in a single wash to attain the same lactose content in the curd as obtained after three washings. Assume perfect washing, and draining of curd to 66% of moisture each time. (10 marks)

(b) Skim milk is prepared by the removal of some of the fat from whole milk. This skim milk is found to contain 90.5% water, 3.5% protein, 5.1% carbohydrate, 0.1% fat and 0.8% ash. If the original milk contained 4.5% fat, calculate its composition assuming that fat only was removed to make the skim milk and that there are no losses in processing. (6 marks)

(c) State the continuity equation of an incompressible fluid. (4 marks)

End of question Paper!!!