NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY

UNIT OPERATIONS

SCH 2208

Supplementary Examination Paper

August 2015

This examination paper consists of 4 printed pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: Graph paper

Examiner's Name: Mr Bothwell Nyoni

INSTRUCTIONS

1. **Answer all questions in Section A and any other three questions from Section B.**
2. **Show steps clearly in any calculation.**
3. **Start the answers for each question on a fresh page.**
4. **Use of calculators is permissible.**

MARK ALLOCATION

QUESTION	MARKS
1.	**20**
2.	**20**
3.	**20**
4.	**20**
5.	**20**
6.	**20**
TOTAL POSSIBLE MARKS	**100**

SECTION A

1 (a) What do you understand by the following terms:

(i) Evaporation
(ii) Distillation
(iii) Leaching
(iv) Drying
(v) Absorption [10 marks]

(b) Give and describe practical examples of the application of any three of the above unit operations. [10 marks]

2 (a) State the law of conservation of mass. In what circumstances does this law fail to hold? [4 marks]

(b) For the distillation column shown in Fig. 1, assume no chemical reaction occurs in the column. The rise in cooling water temperature is limited to 30 ^{o}C. Column operates at 1 bar. The energy supplied to the reboiler is 286 kW. The condenser is in the form of a heat exchanger with cooling water flowing through the shell. Perform mass and energy balance calculations to determine: (i) bottoms and distillate product flows (ii) the amount of heat that must be removed in the condenser and (iii) the cooling water flow. Specific heat capacity of the feed stream (F) and water (W) is 4.0 and 4.2 kJ/kgK respectively.

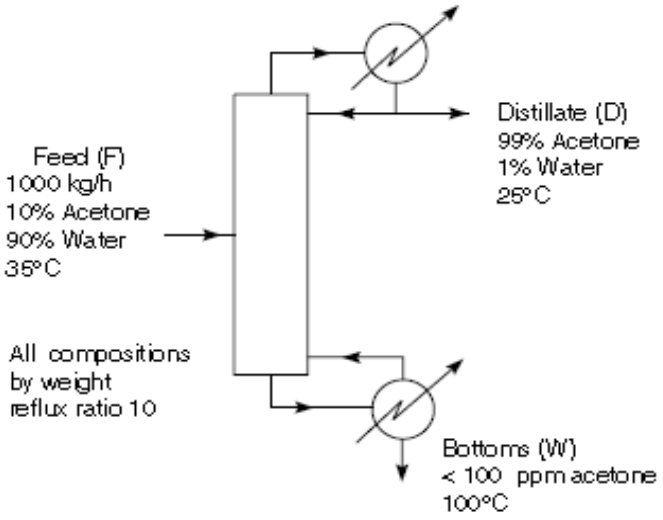

Fig 1 [16 marks]

SECTION B

3 (a) State the three methods of operating evapourators. [3 marks]

(b) A 15 wt% aqueous salt solution is concentrated to 4 wt% in a single-effect evaporator. The feed rate to the evaporator is 7500 kg/h and the feed is at 85^{o}C. The evapourator operates at 1.0 bar. Saturated steam at 170 kPa (115^{o}C) heats the evapourating solution. What heat transfer area is required if the heat transfer coefficient is 2500 W/m^{2}K. Assume that the BPR is zero.

Data from steam tables:
Specific heat capacity of 15% aqueous salt = 3.65 kJ/kgK
Specific heat capacity of 4% aqueous salt = 3.98 kJ/kgK
Enthalpy of steam at 1.0 bar = 2675 kJ/kg [8 marks]

(c) With the aid of diagrams, explain the terms (i) single effect and (ii) multiple effect evaporators. [6 marks]

(d) In a multiple effect evapouration system, state and explain the method of operation you would choose for the last evapouration stage. [2 marks]

(e) State one advantage of multiple effect evapouration compared to single effect evapouration. [1 mark]

4 (a) State two methods of distilling two component mixtures. [2 marks]

(b) State Dalton and Raoult's laws. [4 marks]

(c) A distillation column is fed with a mixture of benzene and toluene, in which the mole fraction of benzene is 0.35. The column is to yield a product in which the mole fraction of benzene is 0.95, when working with a reflux ratio of 3.2, and the waste from the column is not to exceed 0.05 mole fraction of benzene. If the plate efficiency is 60 per cent, estimate the number of plates required. The relation between the mole fraction of benzene in liquid and in vapour is given in Table 1:

Table 1

Mole fraction of benzene in liquid (x)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Mole fraction of benzene in vapour (y)	0.20	0.38	0.51	0.63	0.71	0.78	0.85	0.91	0.96

[14 marks]

5 (a) Explain how the following factors affect the rate of leaching.

(i) Temperature

(ii) Particle size [6 marks]

(b) With the aid of a flowchart describe the steps in a gold mining process. Show clearly on your diagram and describe in detail, where a leaching process is employed. [14 marks]

6(a) A granular material containing 40% moisture is fed to a countercurrent rotary drier at a temperature of 295 K and is withdrawn at 305 K, containing 5 per cent moisture. The air supplied, which contains 0.006 kg water vapour per kg dry air, enters at 385 K and leaves at 310 K. The drier handles 0.125 kg/s wet stock. Assuming that radiation losses amount to 20 kJ/kg dry air used, determine the mass flowrate of dry air supplied to the drier and the humidity of the exit air.

The latent heat of water vapour at 295 K is 2449 kJ/kg, specific heat capacity of dried material is 0.88 kJ/kg.K, the specific heat capacity of dry air is 1.00 kJ/kg.K, and the specific heat capacity of water vapour is 2.01 kJ/kg.K.

[20 marks]

END OF QUESTION PAPER!!!