NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE
END OF SECOND SEMESTER EXAMINATIONS – MAY 2014
UNIT OPERATIONS – SCH 2208
TIME: 3 HOURS

Instructions to candidates:

1. Answer all questions in Section A and any three questions in Section B.
2. Show all your steps clearly in any calculation.
3. Start the answers for each question on a new page.

Extra material:

1. Graph paper

SECTION A

1 (a) (i) What do you understand by the term unit operation? [4]

(ii) Describe three examples of unit operations. [9]

(b) List practical examples of the application of any three of the unit operations you mentioned in (a) (ii). [3]

(c) What will be the most suitable method for separating a mixture containing benzene and naphthalene? Explain your answer. [4]

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

(b) 2000 kg of a 5 per cent slurry of calcium hydroxide in water is to be prepared by diluting a 20 per cent slurry.

(i) Draw a block diagram with all the stream details describing this process.

(ii) Perform mass balance calculations to determine the quantities required. The percentages are by weight. [12]

(c) By use of equations define the terms yield and conversion [4]

SECTION B

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

(b) A single-effect evaporator is used to concentrate 17 kg/s of a solution from 10 to 45 per cent solids. Steam is available at a temperature of 394K with enthalpy of 2530kJ/kg and evaporation takes place at 13.5 kPa and the total enthalpy of steam is 2594 kJ/kg (at this pressure water boils at 325K). The overall coefficient of heat transfer is 3 kW/m^2 deg K, the feed to the evaporator is at 294 K and the condensate leaves the heating space at 355 K. The specific heats of 10 and 50% solutions are 3.76 and 3.14 kJ/kg.K respectively. The specific enthalpy of condensed steam is 4.18 KJ/kg.K.

Estimate:
(i) the amount of steam used and
(ii) the area of heat transfer for the evaporator. [8]

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

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

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

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

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

(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]

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

(i) Temperature

(ii) Particle size [6]

(b) Describe, with use of a diagram if necessary, any one leaching equipment of your choice. [4]

(c) In a pilot scale test using a vessel 1 m^3 in volume, a solute was leached from an inert solid and the water was 75 per cent saturated in 100 s. If, in a full-scale unit, 500 kg of the inert solid containing, as before, 28 per cent by mass of the water-soluble component, is agitated with 100 m^3 of water, how long will it take for all the solute to dissolve, assuming conditions are equivalent to those in the pilot scale vessel? Water is saturated with the solute at a concentration of 2.5 kg/m^3. [10]

6 (a) State three reasons for drying products in processing industry. [3]

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

(c) Describe any two industrial equipment used for drying. [6]

END OF QUESTION PAPER!!!