CHUKA UNIVERSITY

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN INDUSTRIAL CHEMISTRY

CHIN 211: INDUSTRIAL UNIT OPERATIONS

STREAMS: B.SC (IND CHEM) **TIME: 2 HOURS**

DAY/DATE: FRIDAY 13/12/2019 **2.30 P.M. – 4.30 P.M.**

INSTRUCTIONS:

- **Answer question ONE (compulsory) and any other TWO questions.**

QUESTION ONE (30 MARKS)

(a) Define the following terms: (3 marks)

(i) Stream
(ii) Open system
(iii) Batch process

(b) An alloy with a mass fraction of 50% cadmium (enters a distillation device at 1000 kg/h and exists as two streams. At steady state, the gas stream contains 454 kg/h of Cd, and the liquid stream contains 472 kg/h of Zn.

(i) Draw a flow sheet for the process. (1 marks)

(ii) Write the mass balances for the process. (1 marks)

(iii) Prepare a ledger for the process. (3 marks)

(c) Discuss the industrial production of carbon and alumina adsorbents. (8 marks)

(d) Describe the construction and operation of drum and spray dryers. (8 marks)

(e) An aqueous solution of sodium hydroxide contains 20% NaOH by mass. It is desired to produce an 8% NaOH solution by diluting a stream of the 20% solution with a stream of pure water.

(i) Calculate the ratios (g O/g feed solution) and (g product solution/g feed solution). (2 marks)

(ii) Determine the feed rates of 20% solution and diluting water needed to produce 2310 1min of the 8% solution. (3 marks)

QUESTION TWO (20 MARKS)

(a) Discuss the following types of evaporators. (8 marks)

(i) Long-tube vertical evaporator
(ii) Forced circulation evaporator

(b) A continuous single-effect evaporator concentrates 9072 kg/h of a 1.0 wt% salt solution entering at 37.8 to a final concentration of 1.5 wt%. The vapor space of evaporator is at 101.325 kPa and the steam supplied is saturated at 143.2 kPa. The overall coefficient U = 1704 W/.K. Calculate the amount of vapor and liquid products and the heat transfer area that is required. Assume the solution has the same boiling points as water. (6 marks)

(c) Describe the following types of distillation. (6 marks)

(i) Flash distillation
(ii) Batch distillation
(iii) Simple steam distillation

QUESTION THREE (20 MARKS)

(a) Discuss the following types of heat exchangers: (8 marks)

(i) Shell-and-tube exchangers
(ii) Double-pipe exchangers

(b) Batch tests were performed in the laboratory using solutions of phenol in water and particles of activated carbon. The equilibrium data at room temperature are given below:

c, (kg phenol/solution)	q, (kg phenol/kg carbon)
0.332	1.150
0.117	0.122
0.039	0.094
0.006	0.059
0.0011	0.045

(a) Using the given data in the table above, determine the absorption isotherm that fits the data.

(4 marks)

(b) A waste water solution having a volume of 1.0 contains 0.21 kg phenol/ of solution (0.21 g/L). A total of 1.40 kg of fresh granular activated carbon is added to the solution, which is then thoroughly mixed to reach equilibrium. Determine the equilibrium values and the percent of phenol extracted. (8 marks)

QUESTION FOUR (20 MARKS)

(a) Discuss the following types of filters: (8 marks)

(i) Bed filters
(ii) Continuous rotary vacuum drum filters

(b) Discuss the design and operation of spray and packed extraction towers. (8 marks)

(c) Acetic acid extracted from water using methyl isobutyl ketone in a perforated-plate tower at 25. The flow rate of the continuous aqueous phase is 120 /h and that of dispersed solvent phase is 240 /h. The interfacial tension is 9.1 dyn/cm. The tray spacing is 1.0 ft and the hole size on the tray is 0.25 in. Estimate the fraction tray efficiency, . (4 marks)
