CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE (IND CHEM)

CHIN 211: INDUSTRIAL UNIT OPERATIONS

STREAMS: **TIME: 2 HOURS**

DAY/DATE: TUESDAY 30/03/2021 **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 (2 marks)

(i) stream (ii) semi-batch process (iii) steady state (iv) closed system

(b) 1000 kg/h of a mixture of benzene and toluene containing 50% benzene by mass is separated by distillation into two fractions. The mass flow rate of benzene in the top stream is 450 kg/h and that of toluene is 475 kg/h. The operation is steady state. Draw a flowsheet and write balances on benzene and toluene (4 marks)

(c) Draw and explain the boiling point diagram for a maximum boiling azeotrope (2 marks)

(d) Describe the following distillation methods (4 marks)

(i) Flash distillation (2 marks) (ii) Differential distillation (2 marks)

(iii) Fractional distillation (4 marks)

(f) State six reasons of evaporation in the chemical industry (2 marks)

(g) Describe the construction and operation of following types of heat exchangers (8 marks)

(i) Concentric-pipe heat exchangers (ii) Cross-flow heat exchangers

QUESTION TWO [20 MARKS]

(a) Two methanol-water mixtures are contained in separate flasks. The first flask contains 40.0 wt % methanol and the second contains 70.0 wt% methanol. Calculate the mass composition of the product if 200g of the first mixture is combined with 150g the second mixture (4 marks)

(b) Describe the operation of back-feed multiple effect evaporators (6 marks)

(c) Describe the construction and operation of the following driers (10 marks)

(i) Spray driers (ii) drum driers (iii) tray driers

QUESTION THREE [20 MARKS]

(a) The Bayer process is used to recover aluminium oxide (Al_2O_3) from bauxite ore. In the first step, alumina (Al_2O_3) is dissolved with NaOH to produce soluble $NaAlO_2$. The residue (red mud) leaves the leaching step as a slurry. The liquid portion of the slurry contains valuable $NaAlO_2$ as a solute and is therefore separated before the red mud is discarded. The red mud slurry enters at a rate of 1000 lb/h with a solids mass fraction of 10%. The red mud composition is undefined and does not change. The liquid part of the inlet slurry consists of water containing two soluble species: wNaOH =11% and $wAlO_2$ =16%. The wash water stream contains wNaoH = 2.0%. The decanted solution stream (free of solids) contains wH_2O = 95% and the washed mud slurry contains 20% solids.

(i) Draw a detailed flow sheet for the process (4 marks)

(ii) Determine the degree of freedom (DOF) for the process (2 marks)

(iii) Calculate the recovery of $NaAlO_2$ in the decanted stream (4 marks)

(b) Discuss the following types of evaporators (8 marks)

(i) Horizontal-tube natural circulation evaporators

(ii) Short-tube vertical evaporators

(c) State two properties of a good adsorbent (1 mark)

(d) Give two common commercial adsorbents (1 mark)

QUESTION FOUR [20 MARKS]

(a) An experiment on the growth rate of certain organisms requires an environment of humid air enriched in oxygen. Three input streams are fed into an evaporation chamber to produce an output stream with the desired composition. A: Liquid water, fed at a rate of 20:0 cm^3/min B: Air (21 mole% O_2, the balance N_2) C: Pure oxygen, with a molar flow rate one-fifth of the molar flow rate of stream B. The output gas is analyzed and is found to contain 1.5 mole% water.

(i) Draw a well labelled flowsheet of the process (4 marks)

(ii) Calculate all unknown stream variables (4 marks)

(b) Discuss the properties and production of the following adsorbents (12 marks)

(i) Activated alumina (ii) zeolites (iii) synthetic resins
