



(University of Choice)

**MASINDE MULIRO UNIVERSITY OF
SCIENCE AND TECHNOLOGY
(MMUST)
MAIN CAMPUS**

**SPECIAL/SUPPLEMENTARY EXAMINATIONS
2021/2022 ACADEMIC YEAR**

**THIRD YEAR FIRST SEMESTER EXAMINATIONS
FOR THE DEGREE
OF
BSc (INDUSTRIAL CHEMISTRY)**

COURSE CODE: SCI 363

COURSE TITLE: INDUSTRIAL CHEMICAL PROCESSES

DATE: Monday 25/07/2022

TIME: 11.00 – 1.00 PM

INSTRUCTIONS TO CANDIDATES

Answer all the Questions

TIME: 2 Hours

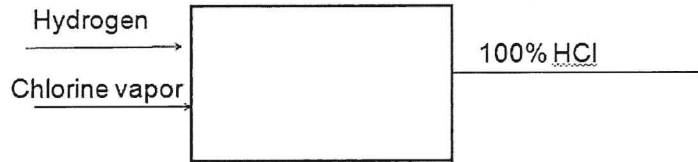
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QUESTION ONE [21 MARKS]

a) Each of the following statements relate to industrial chemical processes. State whether the statement is **True** or **False**. Give a reason for your answer. [10 Marks]

(i) Chemical absorption will be the most suitable technique in separating out the products in the process below.



(ii) Chemical or biochemical plant operated in discontinuous process.

(iii) A separation process increases the speed of the reaction.

(iv) Reverse osmosis occur because a reverse pressure greater than the osmotic pressure is applied

(v) Packing the column help increases the mass transfer by breaking the large droplets thus increasing interfacial area.

b) Mass transfer –based separation processes have wide application in in industry. Name the operations which involve the following phase changes: [6 Marks]

(i) Vapour phase to liquid phase

(ii) Gas phase to liquid phase

(iii) Liquid phase to gas phase

(iv) Liquid phase to another liquid phase

(v) Gas phase to solid phase

(vi) Wet solid to gas phase

c) Calculate the diffusion rate of water through a stagnant film of air, 3 mm thick, when the water is maintained at 29.5°C and atmospheric pressure is 101.3 kPa. The partial pressure of water vapour in the bulk air stream is 1.00 kPa. The diffusivity of water vapour in air is $25.5 \times 10^{-6} \text{ m}^2 \text{ s}^{-1}$ at 29.5 °C. [5 Marks]

QUESTION TWO [17 MARKS]

a) With reference to your knowledge in Industrial Chemical Processes, name the processes described below. [3 Marks]

(i) Technique used when a separation operation is accompanied by chemical reaction that facilitates separation.

- (ii) Transport of matter on a molecular scale through a stagnant fluid, in a direction perpendicular to the main flow.
 - (iii) Mass transfer processes involving bulk fluid motion.
- b) Briefly explain the principle behind the following mass transfer techniques? [4 Marks]
- (i) Electrophoresis
 - (ii) Distillation
 - (iii) Dialysis
 - (iv) Chromatography
- c) Caffeine is used to restore mental alertness or wakefulness during fatigue or drowsiness. Caffeine is also found in some headache and migraine medications, in certain dietary supplements used for weight loss, and in many popular energy drinks. Write four properties of a good solvent for extraction Caffeine from tea. [4 Marks]
- d) Ammonia is diffusing through a stagnant mixture consisting of one third Nitrogen and two-thirds Hydrogen by volume. The total pressure is 1.00 atm and the temperature is 200°C. Calculate the rate of diffusion of ammonia through a film of gas 0.5mm thick, when ammonia concentration changes across the film is 12% and 7% by volume. The diffusivities at 200°C and 1 atm pressure are $D_{AB} = 5.391 \times 10^{-5} \text{ m}^2/\text{s}$ and $D_{BC} = 1.737 \times 10^{-4} \text{ m}^2/\text{s}$ [6 Marks]

QUESTION THREE [18 MARKS]

- a) Define the following as used in mass transfer processes. [4 Marks]
- (i) Mass transfer coefficient
 - (ii) Height of transfer units (HTU).
 - (iii) Number of transfer units (NTU)
 - (iv) Height of packed towers
- b) A gas from a petroleum distillation column has its concentration of H_2S reduced from 0.03 kgmol H_2S / kgmol inert gas to 1 % of its value by scrubbing with a triethanol amine with water as a solvent in a counter current tower of height 7.79 m operating at 300°C and 1 atm. The equilibrium relation is $Y = 2 X$. Pure solvent enters the tower and leaves containing 0.013 kg mole H_2S / kgmol of solvent. If the flow of inert hydrocarbon gas is 0.015 kgmol/ m^2S and the gas phase controls the mass transfer.
- (i) What is a counter current tower? [2 Marks]

- (ii) What do you understand by the term *scrubbing*? [1 Mark]
- (iii) Briefly explain what you understand by the statement “*the gas phase controls the mass transfer*” [2 Marks]
- (iv) Determine equilibrium relation for this process. [2 Marks]
- (v) Calculate number of transfer units in this process [3 Marks]
- (vi) Calculate the height of transfer units in the process [3 Marks]
- (vii) Hence, determine the overall coefficient for absorption. [1 Mark]

QUESTION FOUR

- a) Briefly explain the effect of each of the following on the diffusivity of gases. [2 Marks]
- (i) Temperature:
- (ii) Pressure
- b) An air-ammonia mixture containing 5% ammonia by volume is absorbed in water in a packed column operated at 20⁰C and 1 atm pressure. So as to recover 98% NH₃. If the inert gas flow rate in the column is 1200 kg/m².hr. calculate
- (i) The minimum mass velocity of water from this column. [3 Marks]
- (ii) The number of transfer units in the column taking the operating liquid rate to be 1.25 times the minimum. [2 Marks]
- (iii) The height of the packed tower taking the overall transfer coefficient $K_G a$ to be 128 kg moles/ m³.hr.atm. The relationship for equilibrium in the column is $y = 1.154 x$, where y and x are in mole fraction units. [3 Marks]
- c) In a binary mixture the vapour pressure of A is 800 mm Hg and that of B is 400 mm Hg. Estimate the vapour composition in equilibrium with the liquid if the composition in liquid phase is 50 mole % A. [2 Marks]