



THE MOMBASA POLYTECHNIC UNIVERSITY COLLEGE

(A CONSTITUENT COLLEGE OF JKUAT)

Faculty of Engineering and Technology

**DEPARTMENT OF MECHANICAL AND AUTOMOTIVE
ENGINEERING**

DIPLOMA IN CHEMICAL ENGINEERING

**ECH 2306
UNIT OPERATION IV**

YEAR 3 SEMESTER II

SPECIAL/SUPPLEMENTARY EXAMINATIONS

SERIES: MARCH, 2012

TIME: 2 HOURS

INSTRUCTIONS TO CANDIDATES:

You should have the following for this examination

- Answer booklet
- Drawing instruments
- Drawing paper A2

This paper consists of FIVE questions.

Question ONE is COMPULSORY

Answer question ONE and any other TWO questions.

Maximum marks for each part of a question are as shown.

This paper consists of ***THREE printed pages.***

Question One

a. Define the following terms

- i. Convection
- ii. Radiation
- iii. Fouling
- iv. Conduction

(4 marks)

b. Fourier equation is expressed as: $\frac{dq}{dt} = -kA \left(\frac{dT}{dx} \right)$, define the symbols in the equation.

(6 marks)

c. Derive the heat transfer equation in a three layered cylindrical pipe

(10 marks)

Question Two

a. Methane diffuses at steady state through a tube containing helium. At point 1 the partial pressure of methane is $p_{A1} = 55\text{kPa}$ and at point 2, 0.03m apart, $p_{A2} = 15\text{kPa}$ and the temperature is 298K. At this pressure and temperature, the value of diffusivity is $6.75 \times 10^{-5} \text{ m}^2/\text{s}$.

- i. Calculate the flux of methane at steady state for equimolar counter-diffusion.
- ii. Calculate the partial pressure at a point 0.02m apart from point 1

(12 marks)

b. Hydrochloric acid (A) Diffuses through a thin film of water (B) 4.0mm thick at 283K. the concentration of HCl at point one on the boundary of the film is 12 wt % (density $\rho_1=1060.7\text{kg/m}^3$) and on the other boundary, at point 2, is 4 wt% ($\rho_2=1020.15\text{kg/m}^3$). The diffusivity of HCl in water is $2.5 \times 10^{-9} \text{ m}^2/\text{s}$. calculate the flux of HCl considering water to be stagnant.

(8 marks)

Question Three

a. Outline the conditions under which distribution law applies in Liquid-liquid extraction

(7 marks)

b. A hot solution containing 5000 kg of Na_2CO_3 and water with a concentration of 25wt % Na_2CO_3 is cooled to 293K, and crystals of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ are precipitated. At 293 K the solubility is 21.5 kg/100kg of total water. Calculate the yield of crystals obtained if 5% of the original water in the system evaporates on cooling. **(13 marks)**

Question Four

- a. A fluid of viscosity 0.185 Ns/m^2 and density of 1676 kg/m^3 flows through a 35 mm of diameter pipe at a rate of $456 \text{ cm}^3/\text{s}$. calculate Reynolds number of the fluid. **(5 mark)**
- b. State and explain three types of plates used in distillation column **(15 marks)**

Question Five

By what percentage would the rate of absorption be increased or decreased by increasing the total pressure from 100 to 200 kN/m^2 in the following cases?

- (a). The absorption of ammonia from a mixture of ammonia and air containing 10% of ammonia by volume, using pure water as solvent. Assume that all the resistance to mass transfer lies within the gas phase.
- (b). The same conditions as (a) but the absorbing solution exerts a partial vapour pressure of ammonia of 5 kN/m^2 . The diffusivity can be assumed to be inversely proportional to the absolute pressure.

(20 Marks)