TECHNICAL UNIVERSITY OF MOMBASA

School of Applied and Health Sciences

DEPARTMENT OF PURE AND APPLIED SCIENCES

UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY IN APPLIED CHEMISTRY-INDUSTRIAL OPTION

ACH 4321: Unit Operation II

SPECIAL/SUPPLIMENTARY

SERIES: JULY 2025 SERIES

TIME: 2 HOURS

DATE: JULY 2025

Instructions to Candidates

You should have the following for this examination

Answer Booklet, examination pass and student ID

This paper consists of **FIVE** questions. Attemptquestion ONE (Compulsory) and any other TWO questions.

Do not write on the question paper.

Question One (30 Marks)

a) Heat exchanger was used to cool oil from 200°C to 145°C using coolant available at 80°C and exit the unit at 120°C. Given same operating conditions, demonstrate whether a counter flow or parallel flow will result in a greater heat transfer rate [Data; $U_o = 70$ J/hr-m^2-°c, $A_o = 75$m^2] (5 **marks)**

b) Distinguish between Maximum and Minimum Boiling Azeotropes **((3 marks))**

c) Thin liquor containing 10% solute was concentrated to 30% solute in triple effect evaporator. Steam was available at 110 ^{0}C in the first effect and the BP of liquid in the last effect was 55^{o}c. calculate the BP of liquid in the first effect for a feed rate of 500 kg

h^{-1} [Data: heat transfer coefficients for the 1^{ST}, 2^{nd} and 3^{rd} effects were 2500, 2000 and 1000 watts m^{-2} $°C^{-1}$ respectively **(4 marks)**

d) State the characteristic of potential flow **(3 marks)**

e) Define Average temperature **2 marks**

f) Discuss

i. conduction and convection as mechanism of heat transfer **(4 marks)**

ii. wet and dry bulb thermometry **(3 marks)**

iii. the performance of evaporators **(4 marks)**

Question Two (20 Marks)

a) Differentiate between

i. Condenser and freezer **(3 marks)**

ii. Gas absorption and Gas desorption **(4 marks)**

b) Outline different causes and remedies of fouling in HE **(4 marks)**

c) 60 mm bore tube of thickness 0.03 mm thick was used as a heat exchanger. Calculate Log Mean Area and rate of heat transfer per unit length, (K =0.055 W/m-^oC) **(5 marks)**

d) Fruit juice was dried from initial moisture content of 70% (wet basis) to final moisture content of 5% (wet basis). Estimate the total drying time. Given critical moisture content as 25% (wet basis) and the time for constant drying as 5 min. **(4 marks)**

Question Three (20 Marks)

a) Given Henry's constant for carbon dioxide in water at 25^{o}C as $1.6x10^5$kPa mole $fraction^{-1}$, calculate the percentage solubility by weight of carbon dioxide in water and at a partial pressure of carbon dioxide of 200kPa above the water. **(5 marks)**

b) Define

i. Minimum boiling mixtures **(2 marks)**

ii. Different types of heat flow **(4 marks)**

c) Discuss contact - equilibrium separations process **(4 marks)**

d) Calculate log mean temperature difference for co-current-flow heat exchanger, which is used to cool oil from 70°C to 40°C using water available at 30°C. The outlet temperature of the water is 36°C. **(5 marks)**

Question Four (20 Marks)

a) Define flocculant and outline on how it can be removed **(3 marks)**

b) A furnace was constructed with an inner 25 cm thick fire brick (k = 0.4 W/mK,) followed by 8 cm thick ceramic blanket insulation (K = 0.2 W/Mk) and, 2 mm thick Steel (K =55 W/mK) as a protective layer. The inside temperature of the fire brick layer was measured at 600^{o} C and the temperature of the outside Steel as 60^{0} C. Calculate the rate of heat loss through the furnace and interface temperature between fire brick and ceramic blanket insulation **(4 marks)**

c) 5% w/v solute was concentrated in an evaporator to 20% w/v solute solution. Thin liquor enters at 298K. Calculate economy of evaporator a feed rate of 5000kg/h (Data: Boiling point elevation = 5 K, Latent heat of condensation of steam = 2185 kJ/kg, Specific heat of feed = 4.187 kJ/ (kg K) and Latent heat of vaporization of water = 2257 kJ/kg, **(4 marks)**

d) Discuss the characteristic of

i. constant drying rate

ii. falling rate period **(4 marks)**

b) Define Viscosity **(2 marks)**

c) differentiate between dilatant and Pseudo plastic fluid **(3 marks)**

Question Five (20 Marks)

a) Explain how fluids deviate from Newton's Law **(3 marks)**

b) A natural product (MW = 150 g/mol) distills with steam at 99 ^{o} C at atmospheric pressure. Calculate the mass of the natural product that co-distills with each gram of water. Given vapour pressure of water as 733 mmHg. **(4 marks)**

c) Sketch 1-2 pass heat exchangers and its temperature- length graph **(3 marks)**

d) Discus

I. the division of flow into the viscous sublayer and buffer layer **(4 marks)**

II. the effect of temperature on the performance of evaporators **(3 marks)**

III. Extraction process **(3 marks)**