TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Applied and Health Sciences

Department of Pure & Applied Sciences

UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY IN APPLIED CHEMISTRY

(INDUSTRIAL OPTION)

BTAC 23 S

ACH 4321: Unit Operation II

END OF SEMESTER EXAMINATION

SERIES; DEC 2024

TIME :2HOURS

DATE : Pick DateDec2024

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

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

Do not write on the question paper. ***Paper One***

QUESTION ONE

a) Explain briefly how the following process are carried out

i. Drying

ii. Evaporation

iii. Distillation **(5 marks)**

b) Define Wet and dry bulb thermometry **(3 marks)**

c) Distinguish between

i. Maximum and Minimum Boiling Azeotropes **(3 marks)**

ii. Viscous sublayer and outer layer **(4 marks)**

iii. Condenser and Heat exchanger **(3 marks)**

d) Define the significant of Reynolds Number **(2 marks)**

e) Water at 10°C was used to cool Organic compound at a rate of 12 kg/h from 150°C to 40°C in a double-pipe counter-flow heat exchanger (6.0 m in length and 2.5 cm in diameter). Calculate;

i. Exit temperature of water

ii. LMTD

iii. Overall heat transfer coefficient. **(5 marks)**

[Data; specific heat capacity and flow rate of water is 4.18 kJ/ kg.K and 540 kg/h respectively, heat capacity of organic compound as cp = 2.2 kJ/kg.K]

f) A single effect evaporator was used to concentrate liquid solution from 1% w/v solute solution to 2% w/v solute solution. Thin liquour at 303K enters evaporater at a mass flow rate of 5000kg/h. The evaporator (A= 69m^2) operates at atmospheric pressure (101.325kPa). Saturated steam was used as heating medium. Using the following data Determine

i. Performance of evaporator in terms of economy

ii. Overall heat transfer coefficient. **(5 marks)**

[Data: Boiling point elevation 5 kelvin, Temperature of steam 149 ^{0}C, Latent heat of condensation of steam = 2185 kJ/kg, Enthalpy of feed at 303K=125.79kJ/k.kg, Latent heat of vaporization of water = 2257 kJ/k and Enthalpy of product = 419.04kJ/k).

QUESTION TWO

a) With the help of pressure - composition curve discus separation of Benzene and toluene by distillation (**5 marks)**

b) Define

i. warping and shrinkage as used during drying of solids **(3 marks)**

ii. Minimum moisture content **(2 marks)**

c) Differentiate between Single and double effect evaporation **(3 marks)**

d) Define flocculant and state how it can be removed **(3 marks)**

e) A furnace wall was constructed with three materials of different thickness and thermal conductivity. The inner material was made up of fire brick 25 cm thick with thermal conductivity of 0.4 W/mK, followed by 8 cm thick layer of ceramic blanket of thermal conductivity 0.2 W/mK, and a 2 mm thick steel protective layer of thermal conductivity 55 W/mK. The inside temperature of the fire brick layer was 600^{o}C and the outside temperature of steel was 60^{0} C. assuming steady state heat transfer with an excellent contact between materials, Calculate

i. the rate of heat transfer

ii. interface temperature between fire brick and ceramic material **(4 marks)**

QUESTION THREE

a) Define Viscosity **(2 marks)**

b) Outline how to achieved uniform distribution of heat in HE **(2 marks)**

c) An IV system supply saline solution at the rate of 0.120 cm^3/s through a needle of radius 0.150 mm and length 2.50 cm. Determine initial pressure needed to cause this flow [Data; viscosity of saline solution = 0.001N-s/m^2, pressure of the blood in the vein is 8.00 mm Hg at 20^{o}C.] **(4 marks)**

d) Define

i. Steady state evaporation **(2 marks)**

ii. Conduction as a mechanism of heat transfer **(3 marks)**

iii. Equilibrium moisture content **(2 marks)**

e) Apple halves were dried from initial moisture content of 70% (wet basis) to final moisture content of 5% (wet basis). Given critical moisture content as 25% (wet basis) and constant drying time as 5 min. Estimate the total drying time. **(5 marks)**

QUESTION FOUR

a) 0.03 mm thick steel tube (K =0.055 W/m-^{o}C) was used as a heat exchanger. The inner and outside temperature of the tube is 398 and 315K respectively. Given diameter of the tube as 60 mm, Calculate

i. Log Mean Area

ii. Rate of heat transfer per length. **(4 marks)**

b) Outline different causes and prevention of fouling in Heat Exchanger **(4 marks)**

c) Differentiate between Turbulence and potential flow **(4 marks)**

d) A natural product (Rmm = 150) distills with steam at 99 C at atmospheric pressure. given vapor pressure of water as 733 mmHg. Calculate the mass of the natural product that codistills with each gram of water at 99 C. **(4 marks)**

e) differentiate between dilatant and Pseudo plastic fluid **(4 marks)**

QUESTION FIVE

a) Crude oil (density = 888 kg/m^{3} $^{)}$) and viscosity = 0.800 kg/m · s) is flowing steadily through through a pipes 0.051 m^{2}**,** 5cm-diameter and 40m long. Determine Reynold number and infer whether the flow through the pipe is laminar. **(4 marks)**

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

c) Outline different causes and prevention of fouling in HE **(3 marks)**

d) Discuss the

i. characteristic of constant drying rate **(3 marks)**

ii. effect of liquid temperature on the performance of evaporators **(3 marks**

b) the working of forced circulation evaporators **(4 marks)**