



MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING

DEPARTMENT: CHEMICAL AND PROCESSING ENGINEERING

MODULE: CHEMICAL ENGINEERING PRINCIPLES

CODE: CHEP 101/HCHE111

SESSIONAL EXAMINATIONS
SEPTEMBER 2021

DURATION: 3 HOURS

EXAMINER: DR M. CHIGONDO

INSTRUCTIONS

1. Answer *all* questions in Section A
2. Answer any *three* questions in Section B
3. Total marks 100

ADDITIONAL MATERIAL:

Steam tables

Section A: 40 Marks

Answer all questions

Question 1

(a) Convert

- i. 120 mg/s to its equivalent in kg/h.
- ii. 200 lbm/s to its equivalent in kg/min.
- iii. Calculate the power of a steam of 100 kg/h flow rate and velocity change from 240 m/s to 30 m/s into kJ/s [6]

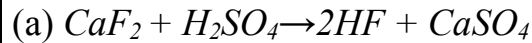
(b) Explain the following:

- i. *recycle*
- ii. *purge*
- iii. *unit operation*
- iv. *process optimization* [4]

Question 2

- a) A gas contains 80 % propane and 15% butane and the rest is water is available as fuel. Determine:
- i. the composition of this gas on wet basis
 - ii. the composition of this gas on dry basis
 - iii. mol of H_2O to moles of dry gas. [6]
- b) A kettle used to boil water containing 1.00 L of water at $20 \text{ }^\circ\text{C}$ is placed on an electric heater ($Q = 2000 \text{ J}$).
- i. Write equation for energy balance for a closed system [1]
 - ii. (ii) Find the time at which water begins to boil, given that:
 $C_{pw} = 4.18 \text{ J/g } ^\circ\text{C}$, density of water 1000 g/L . [4]

Question 3



If 600 mol/s of CaF_2 and 900 mol/s of H_2SO_4 are fed to the factor

- (i) What is the *limiting reactant*? [2]
- (ii) Calculate the % by which the other reactant is in excess. [2]
- (iii) Calculate the composition of the exist stream at 80% conversion of the limiting reactant [5]

(b) Show that the following equations are dimensionally consistent:

- i. Bernoulli's equation $p + h\rho g + \frac{1}{2}\rho v^2 = k$
- ii. $x(\text{m}) = x_0(\text{m}) + 0.308 \left(\frac{\text{m}}{\text{ft}}\right) v \left(\frac{\text{ft}}{\text{s}}\right) t(\text{s}) + 0.5a\left(\frac{\text{m}}{\text{s}^2}\right) t(\text{s}^2)$ [4]

(c) (i) What is a *flow chart*? [2]

(ii) What must be done to obtain maximum benefit from a flow chart? [2]

(d) Define

- (i) *process*
- (ii) *process stream* [2]

Section B

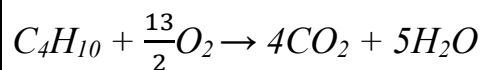
Answer any **three** questions, each question carries 20 marks

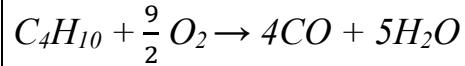
Question 4

a) Briefly explain the following:

- i. *continuous process*
- ii. *batch process*
- a. *steady state process*
- iv. *make up* [4]

b) 100 mol of butane (C_4H_{10}) is burnt with 50 % excess air. The reactions are given below:





The conversion of butane is 80% and 25% of butane reacted forms CO and the rest forms CO₂.

What is

- (i) *excess air*
 - (ii) *theoretical air*
 - (iii) *composition*
 - (iv) *selectivity?* [4]
- c) Determine:
- 1. The feed rate of air [2]
 - 2. The amount of butane that formed CO [2]
 - 3. The composition of the product stream on wet basis [8]

Question 5

- i. A 300 MW power plant burns coal to water producing saturated steam at 60 bars. This steam is expanded in a turbine to steam at 200 °C and 1 bar. The steam enters the turbine at 10 m/s and exits 5 m below entrance level at 100 m/s. The turbine is connected to an electrical generator by a shaft. The efficiency of the turbine is 80 %.
 - i. Draw and label the flow diagram of the process. [1]
 - ii. What is the work done by the turbine? [2]
 - iii. How much heat is lost to the surroundings from the turbine (MW)? [2]
 - iv. What is the mass flow rate of the steam in the turbine? [4]
- ii. Steam (1500 kg/h) at 10 bars and 380 °C is fed to a turbine that operates adiabatically and at steady state. The steam leaves the turbine at 1.0 bar and 150 °C and is cooled in a heat exchanger to a saturated liquid.

- i. Draw and label the process. [1]
- ii. Calculate the work output the turbine [6]

(c) The 1000 kg/h mineral ore if containing 5 % water fed into a double cone. After drying, 90 % of the water has been removed. Calculate the final batch composition and the weight of water removed. [4]

Question 6

- (a) State and explain the equation for energy balance for a closed system. [2]
- (b) Give two uses of energy balance in chemical processes. [2]
- (c) List any **three** energy loss components in a chemical plant. [3]
- (d) (i) What is a *transient process*? [1]
 - (ii) Give *two examples* of transient systems. [2]
 - (iii) Write an equation for material balance for transient system. [3]
- (iv) A tank contains 50 000 liters of waste (tails) from mineral processing system. The amount of solids present in the tank is 2 500 kg. Water is to be added to this tank in order to flush the solids out before discharging the waste into a dam. The water enters the tank at a rate of 3000 L/h. Find the final concentration of solids in the tank after 5 hours of flushing if the water used for flushing leaves at same rate as entry. [7]

Question 7

- a) State any *four* reasons for recycling in chemical processes [4]
- b) Fresh feed stream flowing at 100 kg/h contains 20% by weight (**K**) in H₂O (**W**). The fresh feed stream is combined with a recycle stream and is fed to an evaporator. The concentrated liquid solution exited the evaporator contains 50%

K is fed to a crystallizer. The crystals obtained from the crystallizer are 96% K and 4% water. The liquid from the crystallizer constitutes the recycle stream and contains 0.6 kg K per 1.0 kg of H₂O. The flowchart is shown in Fig 1.

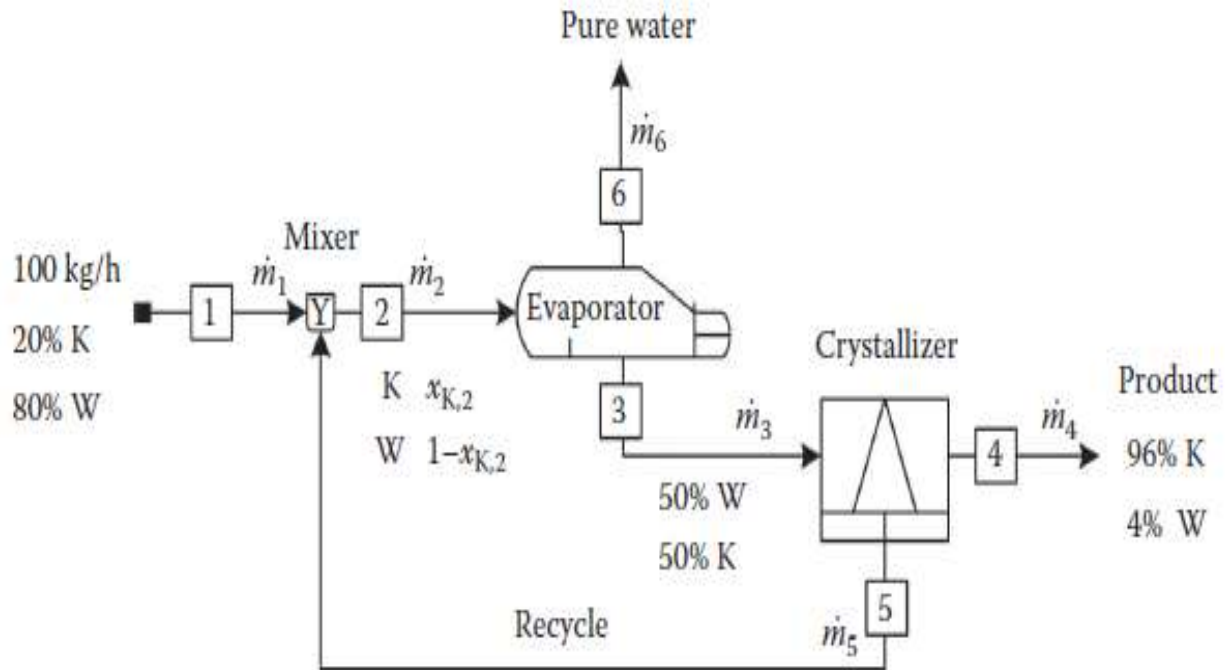


Fig. 1

Determine all the stream flow rate values and compositions. [8]

c) A fluid is flowing through a circular pipe at a flow rate of 3.0 m/s. The density of the fluid is 0.80 kg/m³. If the inside diameter of the pipe is 0.10 m, what is the flow rate fluid in kg/h? [4]

d) If 50 000 kg of crushed ore containing 3.6 % platinum is to be separated in a 5-hour period into tails with 0.4% platinum and metal grade with 80 % platinum, what are the flow rates of the two output streams from a continuous centrifuge which accomplishes this separation? [4]

END OF EXAM