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 °C is placed on an electric heater (Q = 2000 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 J/g ˚C, density of water 1000 g/L. [4]

Question 3

(a) $CaF_2 + H_2SO_4 \rightarrow 2HF + CaSO_4$

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. $x(m) = x_o(m) + 0.308\ (\frac{m}{ft))}) v\ (\frac{ft}{s})\ t(s) + 0.5a(\frac{m}{s^2})\ t(s^2)$ [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 sate process* iv. *make up* [4]

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

$C_4H_{10} + \frac{13}{2}O_2 \rightarrow 4CO_2 + 5H_2O$

$C_4H_{10} + \frac{9}{2} O_2 \rightarrow 4CO + 5H_2O$

The conversion of butane is 80% and 25% of butane reacted forms CO and the rest forms CO_2.

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 H_2O **(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 H_2O. The flowchart is shown in Fig 1.

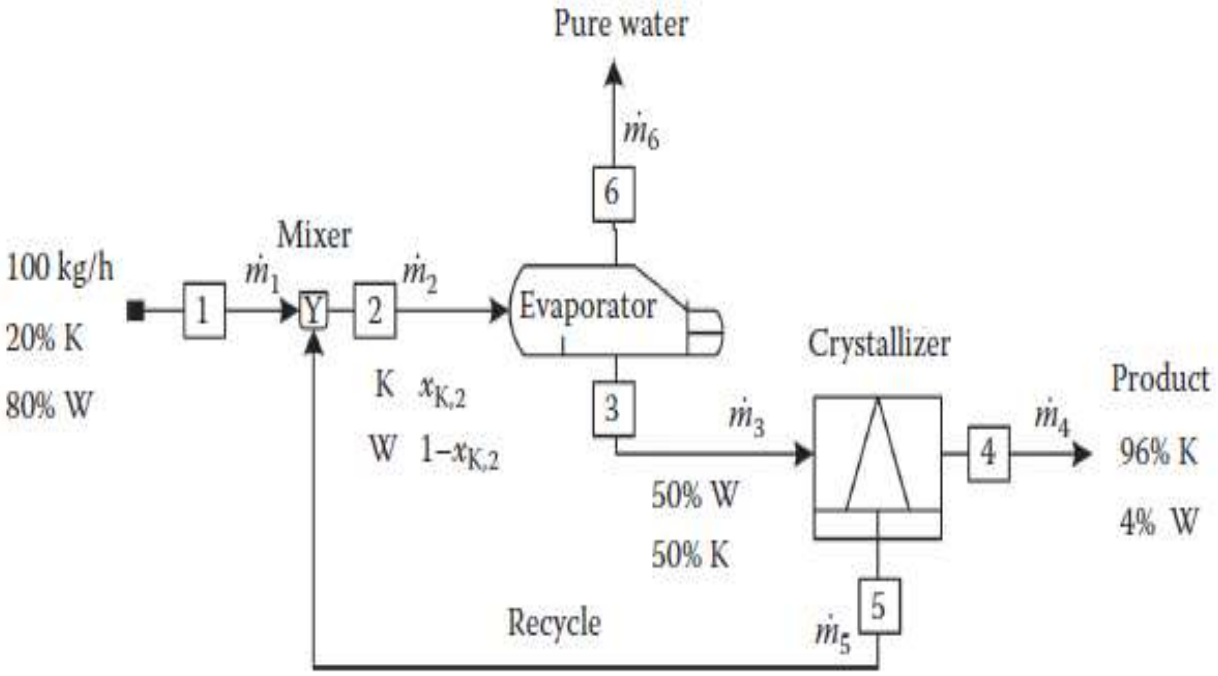

Fig. 1

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/m^3. 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