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PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Midterm Examination : Semester I — Academic year : 2015

Date : 8 September, 2015 — Time : 09.00 – 12.00 AM

Subject : 231-201Material and Energy Balances — Room : R201

รายละเอียดการทำข้อสอบ

1. ห้ามนำข้อสอบบางส่วนหรือทั้งหมดออกจากห้องสอบ
2. นำหนังสือหรือเอกสารเข้าห้องสอบได้
3. ห้ามหยิบยืมเอกสารใดๆ และพูดคุยกับนักศึกษาอื่นขณะทำข้อสอบ
4. ข้อสอบมีทั้งหมด 6 ข้อ มีจำนวนทั้งหมด 7 หน้า
5. อนุญาตให้ทำข้อสอบด้านหลังกระดาษคำตอบแต่ละข้อได้
6. กรอกชื่อและ Code นักศึกษาด้านหน้าข้อสอบและกรอก Code นักศึกษาทุกหน้าของกระดาษ

ข้อที่	คะแนนเต็ม	คะแนนที่ได้
1	20	
2	20	
3	20	
4	20	
5	20	
6	20	
รวม	120	

อ.จันทิมา ชั่งสิริพร

ผู้ออกข้อสอบ

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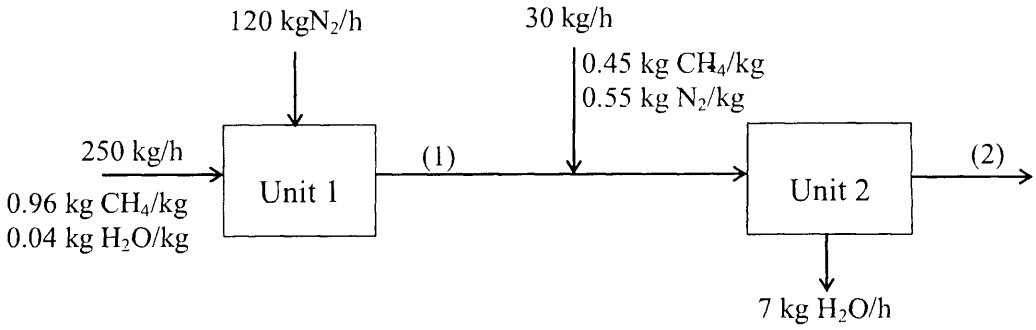
1. Three input streams (A, B, and C) are fed into a condenser to produce 2 output streams of liquid water and gas product. The gas product is found to contain 0.5 mole% water.

A : Humid air 120 mole/h (2 mole % water, 19 mole % O_2, the balance N_2)
B : Pure O_2 50 mole /h
C : Pure N_2, with a molar flow rate 1/3 of the molar flow rate of stream A

Draw and label a flowchart of the process, and calculate all unknown stream variables. (20 marks)

2. A labeled flowchart of a continuous steady state two-unit process is shown below. Show the detail of calculation for the two streams whose flow rates and compositions are not known as labeled (1) and (2). (20 marks)



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3. Reactor is continuously run by the reaction: $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$

The feed contains 20.0 mole% C_4H_8, 48.0% O_2, and balance CO_2. Fractional conversion (f) at 0.65 of the limiting reactant is achieved. Draw the process diagram of this reactor and determine: (20 marks)

a) Which reactant is limiting?
b) The percentage of the other reactants is in excess?
c) The molar amounts of all products using extent of reaction or balance on molecular species?

4. Ethylene (C_2H_4) is produced from ethane (C_2H_6) by feeding a gas stream at flow rate of 250 mole/h. The reactions can be shown as following:

$$C_2H_6 \rightarrow C_2H_4 + H_2 \qquad (1)$$

$$C_2H_6 + H_2 \rightarrow 2CH_4 \qquad (2)$$

The feed stream contains 70.0 mole% C_2H_6, 25.0 mole% H_2 and balance N_2. Fractional conversion (f) of C_2H_6 is 0.55 and CH_4 is produced at 30 mole/h. (20 marks)

a) Draw the process diagram of this reactor.
b) Flow rate of each gas in the product stream?
c) What is the percentage yield of C_2H_4 in this reaction?
d) What is selectivity of C_2H_4 to CH_4 production?

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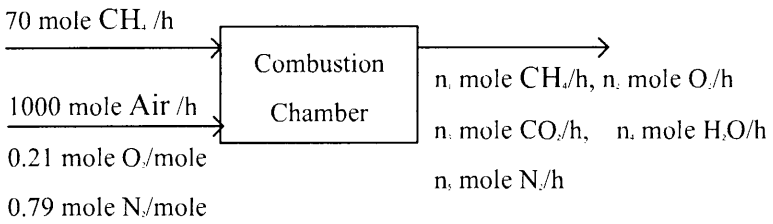
5. Fuel of CH_4 and air are continuously fed to combustion chamber at flow rate of 70 mole/h and 1000 mole/h, respectively. The combustion reaction: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ (20 marks)

a) What is the theoretical air flow rate required if complete combustion occurs?
b) What is % excess air supplied to the system?
c) What is the air flow rate required if $f = 0.75$ (fractional conversion) of the CH_4 reacts?
d) According to question c), calculate the molar flow rate of the flue gas and gas composition on *dry basis*?



6. Liquid ethanol (C_2H_6O) is fed at 150 mole/min into a heater chamber, where ethanol evaporates into a N_2 stream (T = 57°C and P_{gauge}= 240 mmHg). The gas leaving the heater is compressed to a pressure of P_{gauge}= 5.0 atm at a temperature of 300°C. The partial pressure of ethanol in this stream is p_a = 470 mmHg. Atmospheric pressure is 760 mm Hg. (20 marks)

a) What is the molar composition of the stream leaving the compressor?

b) What is the volumetric flow rate of the N_2 entering the evaporator?