

ชื่อ.....รหัส.....

PRINCE OF SONGKLA UNIVERSITY  
FACULTY OF ENGINEERING

Final Examination: Semester I

Academic year : 2015

Date : 13 December, 2015

Time : 13.30 – 16.30 AM

Subject : 231-201 Material and Energy Balances

Room : R201

รายละเอียดการทำข้อสอบ

1. ห้ามนำข้อสอบบางส่วนหรือทั้งหมดออกจากห้องสอบ
2. นำหนังสือหรือเอกสาร เครื่องคิดเลขเข้าห้องสอบได้
3. ห้ามหยิบยืมเอกสารใดๆ และพูดคุยกับนักศึกษาอื่นขณะทำข้อสอบ
4. ข้อสอบมีทั้งหมด 6 ข้อ มีจำนวนทั้งหมด 7 หน้า
5. อนุญาตให้ทำข้อสอบด้านหลังกระดาษคำตอบแต่ละข้อได้
6. กรอกชื่อและรหัสนักศึกษาด้านหน้าข้อสอบและกรอกรหัสนักศึกษาทุกหน้าของกระดาษ

ทุจริตในการสอบโทษขั้นต่ำ คือ ปรับตกในรายวิชาที่ทุจริตและพักการเรียน 1 ภาคการศึกษา

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

รศ.ดร.จันทิมา ชั่งศิริพร  
ผู้ออกข้อสอบ

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1. (20 marks) Air stream ( $350 \text{ m}^3/\text{h}$ ) flows in a pipe at saturation condition ( $70^\circ\text{C}$ , and  $5.6 \text{ atm abs}$ ).

- a) What is the partial pressure of the water in the humid air?
- b) Percentage and volumetric flow rate of water in the air stream?
- c) If pressure and temperature of the air is decreased to  $2,000 \text{ mmHg gauge}$  and  $30^\circ\text{C}$ , respectively? What is the condition of this humid air?
- d) After the gas system from question c) getting to the new saturation, explain for the final condition (% water) of the air stream?

2. (20 marks) Humid air flow to the process system at 100 kg/h and 40°C ( $T_{db}$ ) has 30% relative humidity (RH). Draw the process of all following condition in Psychrometric chart.

Calculate and explanation:

- a) Saturation temperature, enthalpy at saturation, and moisture content of the humid air?
- b) If the humid air is cooled down until the temperature 30°C (at constant moisture content), what is new saturation temperature and amount of heat is removed from this air (kJ/h)?
- c) If moisture content of the humid air from b) is decreased to 0.010 kg/kg DA at constant temperature. What is the new relative humidity,  $T_{wb}$  of the air, and quantity of condensed water?

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3. (20 marks) Factory wants to reduce water (500 kg/h) temperature to 35°C using cooling tower unit. Air at flow rate of 1,300 m<sup>3</sup>/h is introduced to the cooling tower at 30°C ( $T_{wb} = 20^\circ\text{C}$ ) and discharged at 33°C ( $T_{wb} = 25^\circ\text{C}$ ). Draw the diagram of this cooling tower and calculate the inlet temperature of water feeding to this cooling tower.

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4. (20 marks) Engineers want to heat up water (100 kg/h) from 30°C to saturated steam at 100°C by heat exchanger. Superheated steam at 200°C, 5.0 atm is used as a source of heat to the heat exchanger and exiting stream of 150°C saturated steam is discharged. Draw the diagram of this exchanger and calculate flow rate of the superheated steam required for this unit. (**Neglect:** The kinetic and potential energies of the all streams.)

5. (20 marks) Calculate the following question.

5.1  $\text{H}_2\text{SO}_4$  solution at concentration of molarity of 2.5 (Density of this solution  $1.645 \text{ g/cm}^3$ )

a) Molality of the  $\text{H}_2\text{SO}_4$  solution

b) Mole fraction of the solution

5.2 Standard Heat of reaction of the reaction between  $\text{NaOH}$  and  $\text{H}_2\text{SO}_4$

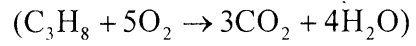
5.3 Water flow from reservoir through pipe and pump at a flow rate of  $20 \text{ m}^3/\text{h}$ .

**Estimate** the pump work (kW) require for sending the water to 5<sup>th</sup> floor of building (4 m/1 floor). Assuming friction losses is neglected.

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6. (20 marks) Propane ( $C_3H_8$ ) 20 mole/h at  $450^\circ C$  is fed to combustion chamber with pure  $O_2$  at  $200^\circ C$ , 1 atm. Excess  $O_2$  of 120% is introduced to the furnace to get the flue gas product at  $600^\circ C$ . Assuming the fractional conversion of the combustion reaction is at 60%.

**Determine:**



- Diagram of the combustion chamber.
- Flow rate and composition of all stream feeding and product of the chamber.
- Heat from the combustion reaction of  $C_3H_8$ .