

King Mongkut's University of Technology Thonburi

Mid-term Examination 1/2550

CHE 103 Material and Energy Balances

2nd year Department of Chemical
Engineering

(Bilingual Program)

Faculty of Engineering

Examination Date: August 9th, 2007

9.00-12.00 a.m.

Instruction

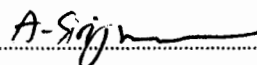
- 1) This examination paper contains 9 pages including the cover page.
- 2) There are totally 5 questions, do all in the examination paper.
- 3) The following items are allowed in the examination room:
 - all types of documents
 - electronic calculator
 - dictionary including the talking dictionary
- 4) Write your name and student identification number on every page.

**After you have finished with the examination, raise your hand for permission to
leave the examination room.**

**Students are not allowed to take the examination paper out of the examination
room.**




(Dr. Ampai Chanachai)
Examiner



(Dr. Amornmart Sirijaruphan)
Examiner

This examination was approved by the Department of Chemical Engineering


(Assist. Prof. Veera Loha)
Department Head

1. (10 points) The heat capacity of a substance at particular temperature can be calculated by using the formula

$$C_p = a + bT + cT^2$$

where C_p is the heat capacity in kJ/mol·K, T is the absolute temperature in K, and a, b and c are constants.

Derive this equation in American engineering units where C_p is in Btu/(lb mole °R) and T is in °R.

Name _____ Stu.ID. _____ Seat No. _____

2. (10 points) Estimate the time in minutes required to fill a 2 -m³ gas tank with N₂ to the pressure of 3000.0 psig at 25°C if filling at a rate of 10 kg/min.

3. (30 points) One thousand liters per hour of a liquid mixture of ethanol and water with 15% by volume of ethanol is mixed with the recycle stream containing 10% ethanol by mass, and the combined stream is fed into the evaporator, where some amount of water is evaporated. The concentrated stream leaving the evaporator contains 30% ethanol by mass; this stream is fed into a distillation column in which it is separated into 2 streams. The top stream contains 85% ethanol by mass and the bottom stream contains 10% ethanol by mass and is recycled to mix with the fresh feed before entering the evaporator.
- Determine the mass flow rate of the overhead product stream.
 - What is the recycle ratio in kg recycle per kg fresh feed?
 - If the bottom stream is not recycled, what would be the mass flow rate of the overhead product stream and the mass flow rate of water evaporated?

4. Fuel containing methane (CH_4) 100 kmol/h and ethane (C_2H_6) 100 kmol/h is fed into the furnace together with air. Concentration of oxygen in outlet flue gas is measured to be 3.0 %mol (dry basis). Carbon monoxide is not found in flue gas stream.
- (5 points) Determine theoretical oxygen
 - (25 points) If all of fuel are burned (100 %conversion), calculate the inlet air flow rate and %excess air.

5. (20 points) 2500 kmol/h of gas mixture containing hydrogen (H_2) and ethylene (C_2H_4) is fed into a Compressor-Cooler Unit at which temperature is controlled at $-124.4^\circ C$. The outlet of Compressor-Cooler Unit is separated into 2 streams, vapor stream (1) and liquid stream (2) which are in equilibrium. Liquid stream (2) has a flow rate of 100 kmol/h and composes of H_2 4 %mol. Determine the concentration of each component in the outlet vapor stream (2) and in the feed stream.

Antoine equation

$$\ln p^* = A - \frac{B}{T + C}$$

p^* = vapor pressure (mmHg)

T = temperature (K)

H_2 : $A = 13.63$ $B = 164.90$ $C = 3.19$

C_2H_4 : $A = 15.54$ $B = 1347.01$ $C = -18.15$