Seat No. 

King Mongkut' University of Technology Thonburi
Final Examination—1/2009
ChE 103 Material and Energy Balances (Bilingual program)

Date: Tuesday 6, October 2009, 13:00-16:00

Notes:

1. This exam paper includes 6 problems (100 points) in a total of 8 pages.
2. It is an open-book/notes examination.
3. A calculator and a ditionary/talking dictionary are allowed.
4. Students are not allowed to take any exam materials/papers out of the exam room.

Student Name_____ Student ID_____

Written by

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This exam paper has been evaluated and approved by the Department of Chemical Engineering's Committee.

Anawat Sungpet

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Interim Departmental Chair

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1. (10 points) Given liquid HF at 20°C and 1 atm as a reference state, the enthalpy of a vapor hydrogen fluoride (HF) is 2,500 J/mol at 20°C and 1 atm, and 6,000 J/mol at 80°C and 1 atm.
   a. Determine the approximate value of $\hat{H}$ for the vapor HF at 20°C and 4 atm
   b. Determine the $\Delta\hat{H}$ for the process indicated below:

   HF (v, 80°C, 1 atm) → HF (v, 20°C, 1 atm)

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2. (15 points) In an adiabatic heat exchanger, saturated steam at 170°C is used to heat a counter-currently flowing stream of acetone vapor from 60°C to 160°C. The flow rate of the acetone is 1,000 standard liters (STP) per minute, and the steam condenses and leaves the heat exchanger as liquid water at 80°C. Calculate the rate of heat transfer from the water to the acetone in kilo-watts.

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3. (15 points) 100 mol/h of methanol vapor at 250°C is condensed to a liquid methanol at 25°C in a condenser. Calculate the rate of heat (kW) that must be transferred from the methanol in the condenser.

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4. (10 points) Calculate the standard heat of formation of liquid nitrobenzene, $C_6H_5O_2N$.

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5. Determine the standard heat of reaction of the following reaction by

   a. Heats of formation (4 points)
   b. Heats of combustion (6 points)

$$CO\,(g) + H_2O\,(g) \rightarrow CO_2\,(g) + H_2\,(g)$$

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6. (40 points) The production of isopropyl alcohol from acetone is shown below.

$$(CH_3)_2CHOH\ (g) \rightarrow CH_3COCH_3\ (g) + H_2\ (g)$$

100 mol/s of isopropyl alcohol vapor is fed to a reactor at 500°C with 90% conversion of isopropyl alcohol. The gas products exit the reactor at 500°C. Determine the heat that must be transferred to or from the reactor. (Assuming a constant pressure at 1 atm; given $\Delta\hat{H}_f^\circ$(isopropyl alcohol (g)) = -272.8 kJ/mol)

Table 1 Specific heat capacities of isopropyl alcohol vapor

Temperature (K)	**C_p, gas (J/mol·K)**
273.15	83.72
298.15	89.32
300.	89.74
400.	112.15
500.	131.96
600.	148.30
700.	161.75
800.	173.04
900.	182.67
1000.	190.97