淡江大學 107 學年度日間部寒假轉學生招生考試試題

系別：化學工程與材料工程學系三年級　　科目：質能均衡　　14-1

考試日期：1 月 13 日(星期日) 第 1 節　　本試題共 4 大題，2 頁

1. Titanium dioxide (TiO_2) is used extensively as a white pigment. It is produced from an ore that contains ilmenite $(FeTiO_3)$ and ferric oxide (Fe_2O_3). The ore is digested with an aqueous sulfuric acid solution to produce an aqueous solution of titanyl sulfate $[(TiO)SO_4]$ and ferrous sulfate $(FeSO_4)$. Water is added to hydrolyze the titanyl sulfate to H_2TiO_3, which precipitates, and H_2SO_4. The precipitate is then roasted, driving off water and leaving a residue of pure titanium dioxide. (Several steps to remove iron from the intermediate solutions as iron sulfate have been omitted from this description.) Molecular weight of Ti and Fe are 48 and 56, respectively. The followings are all reaxtions:

   $FeTiO_3 + 2H_2SO_4 \rightarrow (TiO)SO_4 + FeSO_4 + 2H_2O$

   $Fe_2O_3 + 3H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 3H_2O$

   $(TiO)SO_4 + 2H_2O \rightarrow H_2TiO_{3(s)} + H_2SO_4$

   $H_2TiO_{3(s)} \rightarrow TiO_{2(s)} + H_2O$

   Suppose an ore containing 24.3% Ti by mass is digested with an 80% H_2SO_4 solution, supplied in 50% excess of the amount needed to convert all the ilmenite to titanyl sulfate and all the ferric oxide to ferric sulfate $[Fe_2(SO_4)_3]$. Further suppose that 89% of the ilmenite actually decomposes. Calculate kmol feeded $FeTiO_3$, the masses (kg) of ore and 80% sulfuric acid solution that must be fed to produce 1000 kg of pure TiO_2. **(30%)**

(Problem 4.44)

2. A Thomas flowmeter is a device in which heat is transferred at a measured rate from an electric coil to a flowing fluid, and the flow rate of the stream is calculated from the measured temperature increase of the fluid. Suppose a device of this sort is inserted in a stream of nitrogen, the current through the heating coil is adjusted until the wattmeter reads 1.25 kW, and the stream temperature goes from 30℃ and 110kPa before the heater to 34℃ and 110kPa after the heater. If the specific enthalpy of nitrogen is given by the formula $\hat{H}$ (kJ/kg) = $1.04[T(℃) - 25]$ What is the volumetric flow rate of the gas (L/s) upstream of the heater (i.e., at 30℃ and 110kPa)? **(20%)**

(Problem 7.20)

3. Three hundred gallons of a mixture containing 75.0 wt% ethanol (ethyl alcohol) and 25% water (mixture specific gravity = 0.877) and a quantity of a 40.0 wt% ethanol—60% water mixture (SG = 0.952) are blended to produce a mixture containing 60.0 wt% ethanol. The object of this problem is to determine V_{40}, the required volume of the 40% mixture. Calculate V_{40}. **(10%)**
   ($1\ ft^3 = 7.48$ gal)　　(Problem 4.10)

4. A mixture containing 65.0 mole% acetone (Ac) and the balance acetic acid (AA) is separated in a continuous distillation column at 1 atm. A flowchart for the operation is as follows:

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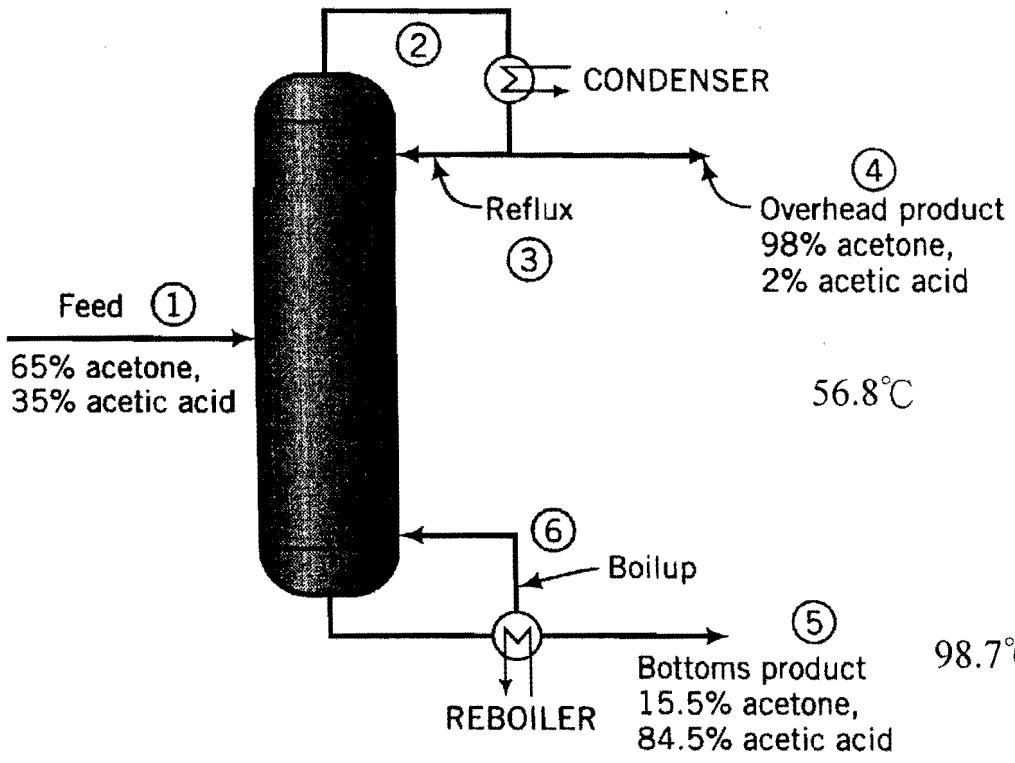

The overhead stream from the column is a vapor that passes through a condenser. The condensed liquid is divided into two equal streams: one is taken off as the overhead product (distillate) and the other (the *reflux*) is returned to the column. The bottom stream from the column is a liquid that is partially vaporized in a reboiler. The liquid stream emerging from the reboiler is taken off as the bottoms product, and the vapor is returned to the column as *boilup*. The bottom product and boilup have the same molar quantity. Negligible heat is lost from the column, so that the only places in the system where external heat transfer takes place are the condenser and the reboiler.

Thermodynamic Data

	$\hat{H}$(cal/mol)			
	Acetone		*Acetic Acid*	
T(°C)	$\hat{H}_l$	$\hat{H}_v$	$\hat{H}_l$	$\hat{H}_v$
56.8	0	7205	0	5723
63.0	205	7322	194	6807
67.5	354	7403	335	6884
98.7	1385	7946	1312	7420

(a) Taking 100 ml of feed as a basis, calculate the quantity of overhead liquid (mol) and net heat requirement (cal) for the process. (You may neglect heats of mixing, although doing so for dissimilar liquids like acetone and acetic acid may introduce some error.) **(20%)**

(b) For the same basis, calculate the required heat input to the reboiler and the required heat removal from the condenser. **(20%)** (Problem 7.42)