



Department of Chemical Engineering
Mid Semester Examination Autumn 2016
Subject: Chemical Process Calculations (CH21103)

Sep, 2016
Time: 2 Hrs
Full Marks: 30

Instructions: Answer all questions. All parts of a question must be answered together. Missing data should be suitable assumed. All assumptions must be stated clearly and explicitly. Please write your name and roll number on all charts/tables immediately after you receive them.

1. A liquid mixture containing 30 mole% benzene (B), 25 mole% toluene (T), and the balance xylene (X) is fed to a distillation column. The bottom product contains 98 mole% X and no B, and 96% of the X in the feed is recovered in this stream. The overhead product is fed to a second distillation column. The overhead product from the second column contains 97% of the B in the feed to this column. The composition of this stream is 94 mole% B and the balance T.

Calculate:

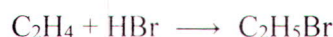
- the percentage of the benzene in the process feed (i.e. the feed to the first column) that emerges in the overhead product from the second column.
- the percentage of toluene in the process feed that emerges in the bottom product from the second column.

[3+3]

2. In a wood drier, the hot air must contain at least 2 wt.% water to prevent the wood from drying too rapidly and splitting or warping. The original fresh air fed contains 1 wt.% water. Wood is dried from 20 wt.% water to 5 wt.% water. The wet air leaving the drier contains 4 wt.% water. Calculate the amount of wet air that must be returned to the drier if 2000 lbm/h of wet wood is dried.

[6]

3. The reaction between ethylene and hydrogen bromide to form ethyl bromide is carried out in a continuous reactor.



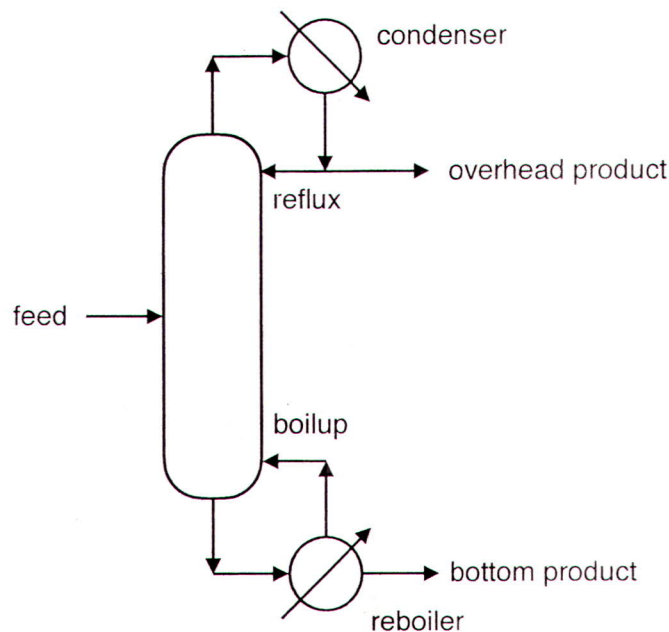
The product stream is analyzed and found to contain 51.7 mole% $\text{C}_2\text{H}_5\text{Br}$ and 17.3% HBr. The feed to the reactor contains only ethylene and hydrogen bromide. Which of the reactant is the limiting reactant and what is its percentage conversion. The molar flow rate of the feed stream is 165 mol/s. Also, estimate the extent of reaction (ξ).

[6]

4. A stream of air at 20°C has a relative humidity of 32%. What is the amount of moisture per kg of dry air. What will be the relative humidity if the stream is heated to a temperature of 40°C. Please mark on the psychrometric chart (attached to the question paper) and attach to your answer script.

[4]

5. An equimolar liquid mixture of benzene and toluene is separated into two product streams by distillation. The vapor stream leaving at the top of the column, which contains 97 mole% benzene, is fed to a condenser to undergo complete condensation. The condensed liquid is split into two equal fractions: one is taken off as the final overhead product stream and the other (the reflux) is recycled to the top of the column. The final overhead product contains 89.2% of the benzene fed to the column. The liquid leaving the bottom of the column is fed to a partial reboiler in which 45% of it is vaporized. The vapor generated in the reboiler (the boilup) is recycled to the column, and the residual reboiler liquid is taken as the final bottom product stream. Assume that the vapor and liquid are in equilibrium.



Using 100 moles of feed as a basis, calculate:

- the molar amounts of the overhead and bottom products and the mole fraction of benzene in the final bottom product.
- if the compositions of the streams leaving the reboiler are governed by the relation:

$$\frac{y_B/(1-y_B)}{x_B/(1-x_B)} = 2.25,$$

where y_B and x_B are the mole fractions of benzene in vapor and liquid streams, respectively. Estimate the temperature of the reboiler, which is at 1 atm. The Antoine's constants for benzene in the temperature range of 80-250°C are $A = 7.2009$, $B = 1415.8$, and $C = 248.028$.

[3+5]



PSYCHROMETRIC CHART

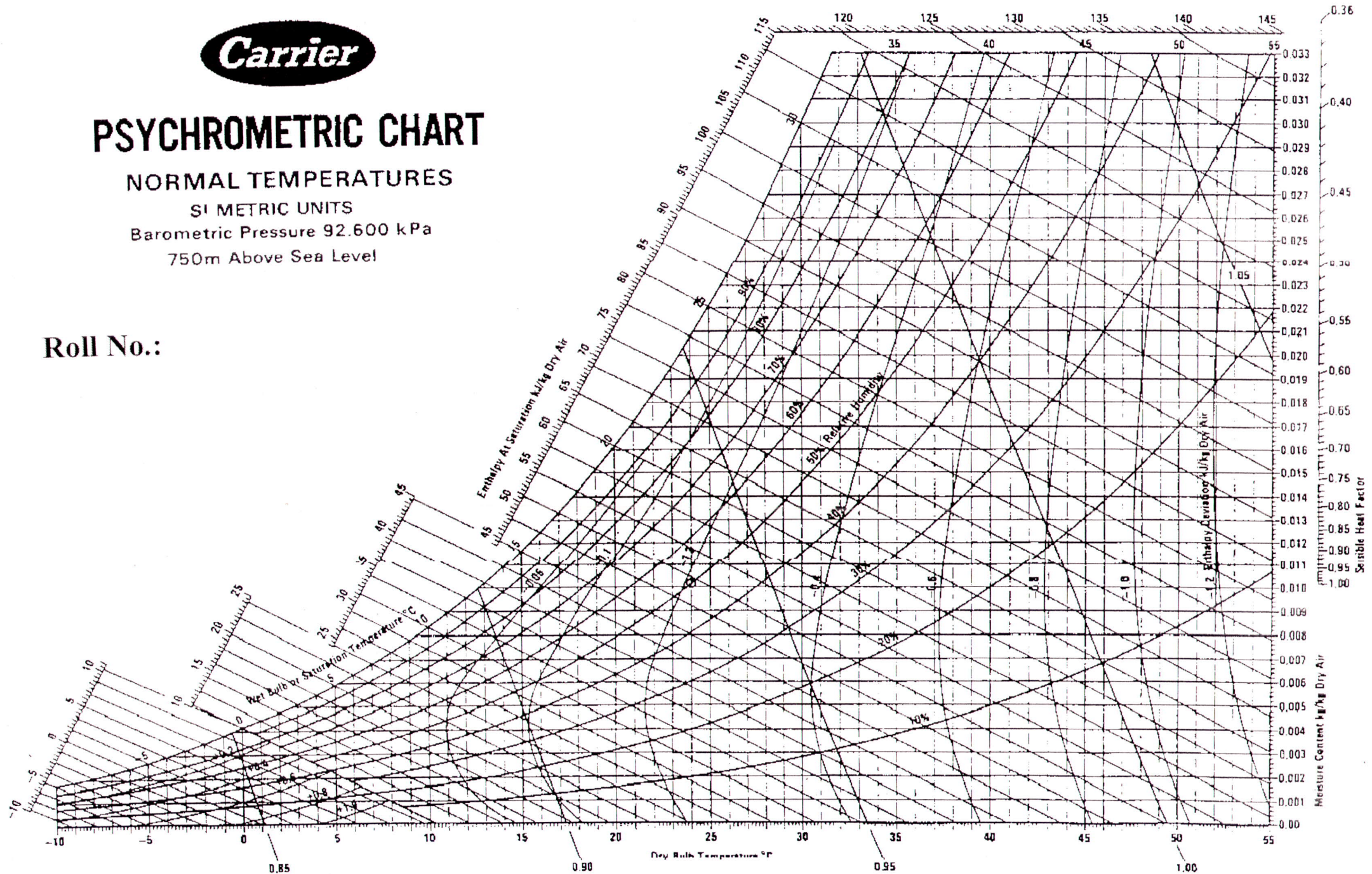
NORMAL TEMPERATURES

SI METRIC UNITS

Barometric Pressure 92.600 kPa

750m Above Sea Level

Roll No.:



Below 0°C Properties and Enthalpy Deviation Lines Are For Ice

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