

# CHE407: Separation Processes

## Tutorial-5

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### QUESTION (1)

A mixture of 50 wt% ethanol and 50 wt% water. The feed is a mixture of two-liquids and one-third vapor is to be distilled at 1.0 atm pressure to a distillate containing 85 wt% ethanol and a bottoms containing 5 wt% ethanol. The feed rate is 500 kg/h and a reflux ratio of 1.5 is to be used. Do as follows using Ponchon-Savarit method:

- Calculate the amount of distillate and bottoms.
- Find the number of theoretical trays needed.
- Find the minimum reflux ratio  $R_m$ .
- Find the minimum number of theoretical plates at total reflux.
- Calculate the condenser and reboiler heat loads in kW.

A.3-22 Equilibrium Data for Ethanol–Water System at 101.325 kPa (1 Atm)\*

Temperature		Vapor–Liquid Equilibria, Mass Fraction Ethanol		Temperature		Vapor–Liquid Equilibria, Mass Fraction Ethanol		Temperature		Enthalpy (btu/lb <sub>m</sub> of mixture)		Enthalpy (kJ/kg of mixture)		
°C	°F	$x_A$	$y_A$	°C	°F	$x_A$	$y_A$	°C	°F	Mass Fraction	Liquid	Vapor	Liquid	Vapor
100.0	212	0	0	81.0	177.8	0.600	0.794	100.0	212	0	180.1	1150	418.9	2675
98.1	208.5	0.020	0.192	80.1	176.2	0.700	0.822	91.8	197.2	0.1	159.8	1082	371.7	2517
95.2	203.4	0.050	0.377	79.1	174.3	0.800	0.858	84.7	184.5	0.3	135.0	943	314.0	2193
91.8	197.2	0.100	0.527	78.3	173.0	0.900	0.912	82.0	179.6	0.5	122.9	804	285.9	1870
87.3	189.2	0.200	0.656	78.2	172.8	0.940	0.942	80.1	176.2	0.7	111.1	664	258.4	1544
84.7	184.5	0.300	0.713	78.1	172.7	0.960	0.959	78.3	173.0	0.9	96.6	526	224.7	1223
83.2	181.7	0.400	0.746	78.2	172.8	0.980	0.978	78.3	173.0	1.0	89.0	457.5	207.0	1064
82.0	179.6	0.500	0.771	78.3	173.0	1.00	1.00							

\* Reference state for enthalpy is pure liquid at 273 K or 0°C.

Source: Data from L. W. Cornell and R. E. Montonna, *Ind. Eng. Chem.*, **25**, 1331 (1933); and W. A. Noyes and R. R. Warfel, *J. Am. Chem. Soc.*, **23**, 463 (1901), as given by G. G. Brown, *Unit Operations*. New York: John Wiley & Sons, Inc., 1950. With permission.

### QUESTION (2)

A mixture of 60 wt% ethanol and 40 wt% water which is saturated vapor at the dew point temperature is to be distilled at 1.0 atm pressure to a distillate containing 85 wt% ethanol and a bottoms containing 10 wt% ethanol. The feed rate is 1000 kg/h and a reflux ratio of 1.6 is to be used. Do as follows using Ponchon-Savarit method:

- Calculate the amount of distillate and bottoms.
- Find the number of theoretical trays needed.
- Find the minimum reflux ratio  $R_m$ .
- Find the minimum number of theoretical plates at total reflux.
- Calculate the condenser and reboiler heat loads in kW.