

Final Exam

Q.1

For a 30 mol% n-pentane and 70 mol% n-hexane, calculate:

- The dew-point temperature at 1 atm.
- The bubble-point temperature at 1 atm.
- The dew-point pressure at 55 °C.
- The vapor fraction at 60 °C and 1 atm, and the mole fractions of the vapor and liquid phases.
- Calculate the adiabatic flame temperature of the mixture at 60 °C and 1 atm being burned with 30% excess oxygen (not air) at 75 °C.

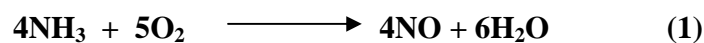
Q.2

A distillation tower is needed to separate an equimolar mixture, at 25 °C and 1 atm, of benzene from styrene. The distillate should contain 99 mol% benzene and 95% of the benzene fed to the tower. If $R = 1.3 R_{\min}$, determine:

- The minimum number of stages at a total condenser.
- The theoretical number of stages.
- The optimum feed stage.
- The reflux ratio.

Q.3

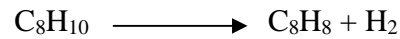
In the nitric acid process, ammonia oxidation is carried out in a catalytic reactor. Two reactions are possible:



At 1000 °C, 92% of the NH_3 can be converted into NO while the remainder goes by reaction (2). What is the heat of reaction at 1000 °C per kg of NH_3 supplied to the reactor if the catalytic burning is with the stoichiometric amount of pure oxygen? What would be the change in the heat of reaction if 10% excess oxygen at 1000 °C [based on reaction (1)] were used? Assume that ammonia and oxygen are fed at 25 °C and 1 atm.

Q.4

Ethylbenzene is converted to styrene by catalytic dehydrogenation reaction



A flow chart of a simplified commercial process is shown below. Fresh and recycled liquid ethylbenzene combine and are heated from 25 °C to 500 °C. The heated ethylbenzene is mixed adiabatically with steam at 700 °C to produce the feed to the reactor at 600 °C. (The steam does not react but used to reduce side reactions and to remove carbon deposited on the catalyst surfaces).

A single-pass conversion of 35% is achieved in the reactor and the products exit at 560 °C. The product stream is cooled to 25 °C, allowing hydrogen to pass out from the flash drum. The water and hydrocarbon liquids are immiscible and are separated completely in a settling tank-decanter. The water is vaporized and heated and then steam is recycled to mix with the ethylbenzene feed to the reactor. The hydrocarbon stream is fed to a distillation tower in which the mixture is separated into essentially pure styrene and ethylbenzene. The ethylbenzene is recycled and cooled to 25 °C before mixing with the fresh feed.

- Calculate on the basis of 100 kg/hr styrene produced, the required fresh ethylbenzene feed rate, flow rate of recycled ethylbenzene, and circulation rate of water all in mols/hr. (assume atmospheric pressure for the process)
- Calculate the required rates of heat input or withdrawal in kJ/hr for the ethylbenzene preheater (A), steam generator (G), reactor (C), condenser (D) and distillation reboiler and condenser.

