

## CHEMICAL ENGINEERING CALCULATIONS – MIDTERM EXAM

**Instruction:** Show all necessary solutions. Box all final answers. All values from solutions to final answers must use 4 decimal places all throughout.

- An aqueous solution of sodium hydroxide contains 20% NaOH by mass. It is desired to produce an 8% NaOH solution by diluting a stream of the 20% solution with a stream of pure water. (a) calculate the ratios (g H<sub>2</sub>O / g feed solution) and (g product solution/ g feed solution). (b) Determine the feed rates of 20% solution and diluting water needed to produce 2310 lb/min of the 8% solution.

- Acrylonitrile is produced by the reaction of propylene, ammonia, and oxygen.



The feed contains 10% mole propylene, 12% ammonia, and 78% air. A fractional conversion of 30% of the limiting reactant is achieved. Determine which reactant is limiting, the percentage by which each of the other reactants is in excess, and the molar flow rates of all product gas constituents for a 30% conversion of the limiting reactant, taking 100 mol of feed as a basis.

- The reactions



take place in a continuous reactor at a steady state. The feed contains 85% mole ethane (C<sub>2</sub>H<sub>6</sub>) and the balance inerts. The fractional conversion of ethane is 0.501, and the fractional yield of ethylene is 0.471. Calculate the molar composition of the product gas and the selectivity of ethylene to methane production.

- Thorium-234 is a radioactive isotope that decays at a rate proportional to the amount present. Suppose that 1 gram of this material is reduced to 0.80 grams in one week.
- On an island, the mouse population doubled during the first 10 years, reaching 50,000. At that time the islanders imported several cats, who thereafter ate 6,000 mice every year. (a) What is the number of mice on the island  $t$  years after the arrival of the cats? (b) How many mice will be on the island 10 years after the arrival of the cats? (c) Normally, the cats' harvest would not remain constant. What will happen if the cats harvest 10% of the current mouse population each year?
- A 600 gallon tank is filled with 300 gal of pure water. A spigot is opened and a salt solution containing 1 lb of salt per gallon of solution begins flowing into the tank at a rate of 3 gal/min. Simultaneously, a drain is opened at the bottom of the tank allowing the solution to leave the tank at a rate of 1 gal/min. What will be the salt content in the tank at the precise moment that the volume of solution in the tank reaches the tank's capacity of 600 gal?
- Air containing 0.005 kg water vapour/ kg dry air is heated to 325 K in a dryer and passed to the lower shelves. It leaves these shelves at 60% humidity and is reheated to 325K and passed over another set of shelves, again leaving with 60% humidity. This is again reheated for the third and fourth sets of shelves after which the air leaves the dryer. On the assumption that the material in each shelf has reached the wet bulb temperature and that heat losses from the dryer can be neglected, determine: (a) the temperature of the material on each tray, (b) the rate of water removal if 5m<sup>3</sup>/s of moist air leaves the dryer, (c) the temperature to which the inlet air would have to be raised to carry out the drying in a single stage.
- Coal fired in a furnace has a heating value of 13800 Btu/lb and contains 78.05% C and 1.2% S. the proximate analysis shows 4% M, 24% FC, 8% ash and the analysis of the refuse shows 8% VCM, 25% FC and 32% ash. Calculate the % of C lost in the refuse.
- Wet solids is to be dried from 40% to 10% in 5 hours under constant drying conditions. The critical moisture content is 20% and the equilibrium moisture content is 7%. All moisture contents are on dry basis. The time needed to dry from 15% to 5% free moisture under the same drying conditions is
- A stoichiometric problem was solved on the basis of 100 moles dry flue gas (DFG). The given condition at the stack outlet are as follows: 780 mm Hg, 970K and the partial pressure of water is 24 mm Hg. The volume of the wet flue gas is

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**H. Scott Fogler**



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