

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI, PILANI CAMPUS
DEPARTMENT OF CHEMICAL ENGINEERING

First Semester 2022-23

CHE F211: Chemical Process Calculations
Comprehensive Examination (Closed Book)

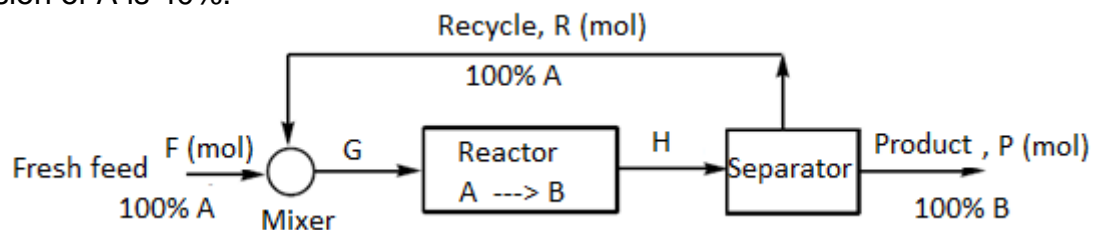
Maximum Marks: 120

Date: 19.12.2022

Time: 180 minutes

Note: All part of a question should be answered together and in sequence. Data booklet with Tables and Charts is allowed.

1. (a) (10 Marks) Define the following terms:
Humidity, dew point, dry-bulb temperature, wet-bulb temperature, humid heat, humid volume, heat of mixing and heat of solution, adiabatic flame temperature, lower heating value and higher heating value, heat of formation and heat of combustion.
(b) (10 Marks) An air-water vapor sample has a dry-bulb temperature 55°C and humidity of 0.03 kg water vapor/kg dry air at 1 std atm pressure. Determine (analytically): molal humidity, relative humidity, humid heat, dew point and specific volume. Obtain the wet-bulb temperature and dew point from the humidity chart.
2. a) (10 Marks) To prepare a solution of 50% sulphuric acid, a dilute acid containing 28% H₂SO₄ is fortified with a purchased acid containing 96% H₂SO₄. How many kilograms of the purchased acid must be brought for each 100 kg of the dilute acid?
b) (10 Marks) Ethane is burned with 50% excess air. The percentage conversion of the ethane is 90%; of the ethane burned, 25% reacts to form CO and the balance reacts to form CO₂. Calculate the molar composition of the stack gas on a dry basis and the mole ratio of water to dry stack gas.
3. (a) (10 Marks) A real gas mixture of 40% H₂ and 60% N₂ is contained in a tank at 850 atm pressure and -45°C temperature. Estimate the specific volume of the mixture. Given critical temperatures (K): H₂ = 33, N₂ = 126.2; Critical pressures (atm): H₂=12.8, N₂=33.5.
(b) (10 Marks) The reaction A → B takes place in the reactor shown in the following system with recycle. Find the moles of recycle (R) per 100 kmol of fresh feed if the single pass conversion of A is 40%.



- (c) (10 Marks) Calculate the theoretical flame temperature for a gas containing 20% CO and 80% N₂ when burned with 150% excess air, both air and gas being at 25°C. Data:
Standard heat of formation in cal/gmol, CO₂: -94,052, CO: -26,412.
Average specific heat, C_{pm} in cal/gmol.°C, CO₂: 12.10, CO: 7.50, O₂: 7.90, N₂:7.55.
4. (15 Marks) Soil contaminated with polyaromatic hydrocarbons can be treated with hot air and steam to drive out the contaminants. If 30 m³ of air at 100°C and 98.6 kPa with a dew point of 30°C are introduced into the soil, and in the soil gas cools to 14°C at a pressure of 109.1 kPa, what fraction of the water in the gas at 100°C condenses out in the soil? Given Antoine's constants for water: A=18.3, B=3816, C=46.

(PTO)

5. (15 Marks) A common method used in manufacturing sodium hypochlorite bleach is by the reaction



A water-NaOH solution that contains 1145 kg of pure NaOH is reacted with 1220 kg of gaseous chlorine. The NaOCl formed weighs 620 kg. Determine

- The limiting reactant.
- The percentage excess of the excess reactant.
- The degree of completion of reaction, expressed as the moles of NaOCl formed to the moles of NaOCl that would have formed if the reaction had gone to completion.

[Atomic weights Cl:35.5, Na:23, O:16, H:1]

6. (20 Marks) Formaldehyde can be made by oxidation of methanol (CH_3OH). If stoichiometric amounts of $\text{CH}_3\text{OH}(\text{g})$ and $\text{O}_2(\text{g})$ enter the reactor at 100°C , the reaction is complete, and the product (formaldehyde and water) leave the reactor at 200°C , calculate the heat that is added or removed from the reactor per g mole of $\text{CH}_3\text{OH}(\text{g})$ fed to the reactor. The reaction is



Take the C_p equations and heat of formation data from the booklet.

~ ALL THE BEST ~