irla Institute of Technology & Science, Pilani
Hyderabad Campus
Chemical Engineering Department

Midsem Examination

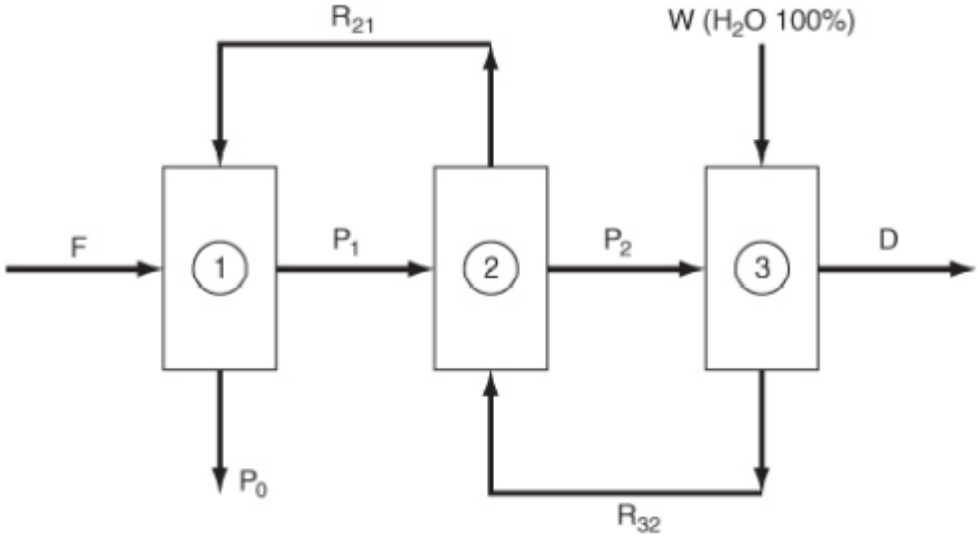
First Semester/2022-23

Course No.: CHE F211 | **Time: 90 mins**
Course Name: Chemical Process Calculations | **Weightage: 30%**
Instructor: Dr. Afkham Mir | **Max Marks: 30**
Exam Type: Open Book

Attempt all questions. Make necessary assumptions wherever required.

Q. 1 A plating plant has a waste stream containing zinc and nickel in quantities in excess of that allowed to be discharged into the sewer. The proposed process to be used as a first step in reducing the concentration of Zn and Ni is shown in the figure below. Each stream contains water. The concentrations of several of the streams are listed in the table. What is the flow (in liters per hour) of the recycle stream R_{32} if the feed is 1 L/hr?

Stream	Concentration (g/L)	
	Zn	Ni
F	100	10
P_0	190.1	17.02
P_2	3.5	2.19
R_{32}	4.35	2.36
W	0	0
D	0.1	1.0



[15 M]

Q.2 In 1916 Nusselt derived a theoretical relation for predicting the coefficient of heat transfer between a pure saturated vapor and a colder surface

$$h = 0.943 \frac{k^3 \rho^2 g \lambda}{L \mu \Delta T}^{\frac{1}{4}}$$

where h is the mean heat transfer coefficient, Btu/[(hr)(ft^2)(°F)],
k is the thermal conductivity, Btu/[(hr)(ft)(°F)],
ρ is the density in lb/ft^3,
g is the acceleration of gravity, 4.17 × 10^8 ft/(hr)^2,
λ is the enthalpy change of evaporation in Btu/lb,
L is the length of the tube in ft,

μ is the viscosity in $lb_m/[(hr)(ft)]$
ΔT is the temperature difference in °F
What are the units of the constant 0.943? [5M]

Q. 3 The drag force, D of a sphere is influenced by, sphere diameter d, flow velocity U, fluid density ρ, and fluid viscosity μ. Derive a rational equation for the drag force in terms of dimensionless groups using Buckingham Pi's method. [5 M]

Q.4 Heat capacities are usually given in terms of polynomial functions of temperature. The equation for carbon dioxide is

$$C_p = 8.4448 + (0.5757 \times 10^{-2}\ T) - (0.2159 \times 10^{-5}\ T^2) + (0.3059 \times 10^{-9}\ T^3)$$

where T is in °F and C_p is in Btu/[(lb mol)(°F)]. Convert the equation so that T can be in °C and C_p will be in J/[(g mol)(K)]. [5M]

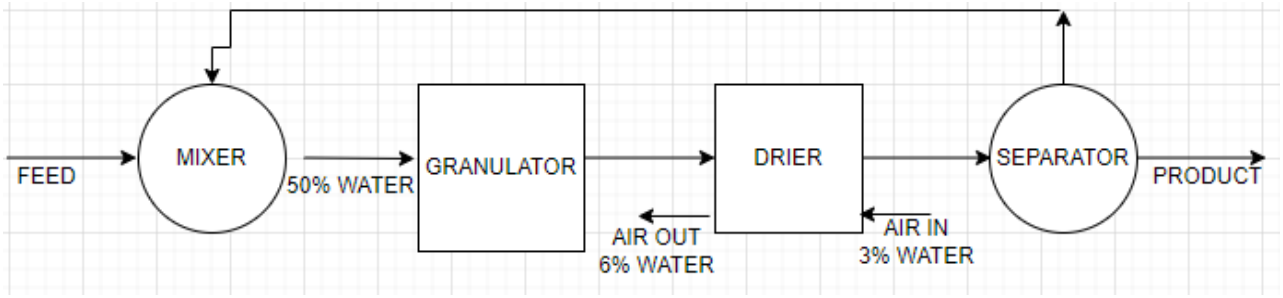
Q.5 A distillation column separates a mixture of ethanol and water into high-purity alcohol and wastewater. The feed is a 20 mol% ethanol and 80 mol% water mixture. The distillate is to contain 85 mol% ethanol and the residue is to have 3 mol% ethanol. Compute
(i) the quantity of distillate and residue produced per 1000 Kg of feed,
(ii) the percentage of alcohol in the feed that has been recovered as distillate. [10 M]

Q.6 Nitrobenzene is produced commercially by nitrating benzene with a mixed acid containing 39% nitric acid, 53% sulphuric acid, and 8% water. A charge is made up of 655 kg of benzene and 1360 kg of mixed acid. The reaction is 95% complete. The reaction is given as

$$C_6H_6 + HNO_3 \rightarrow C_6H_6NO_2 + H_2O$$

Calculate (i) the quantity of nitrobenzene produced, and (ii) the quantity and quality of the spent acid [10 M]

Q.7 A plant produces material at the rate of 4000 kg/h containing 75% water and 25% solids. The material is first granulated and then dried to a final moisture content of 16.67%. The feed to the granulator must have a water content of 50% only. For this, fresh feed is mixed with part of the final product leaving the drier. Air entering the drier contains 3 % moisture, while air leaving the drier contains 6% moisture. Compute the recycle rate to the granulator and the rate of hot air flow to the drier.



[10 M]