Bachelor of Chemical Engineering 1st year 1st Semester Examination, 2017 (OLD)

Outlines of Chemical Engineering

Time: 3h Full Marks: 100

Answer any five questions

Assume any missing data

1. (a) The *n+1* data points $(x_0, y_0), (x_1, y_1), ..., (x_n, y_n)$ are to be fitted through the 'best' straight line $y = a_0 + a_1 x$. Derive the expression to estimate the magnitude of a_0 and a_1 from the data. (8)

   (b) Use Newton's Interpolation formulae (backward difference) to relate y and x for the following data points (12)

y	-2	-1	0	1	2
x	-16	-19	-20	-13	8

2. (a) The mass fraction of the components of a gas mixture comprising of CO_2, CO, O_2 and N_2 are 5%, 30%, 25% and 40% respectively. Determine the average molecular weight of the gas mixture. (6)

   (b) A water solution containing 5 wt% NaoH (stream *A*) is added to another solution (stream B) containing 25 wt% NaoH flowing at 2 kg/min. The product of the combination leaves at 10 kg/min.

   (i) What is the composition of the mixed stream and the flow rate of stream *A*?

   (ii) What is the volumetric flow rate of the mixed stream (m^3/min)? (8)

   The density of NaoH is related to the %w/w NaOH (w) by the following equation

$$\rho(\mathrm{g/cm^3}) = 0.0107w + 1.0022$$

   (c) Convert $\dfrac{6(\mathrm{in})(\mathrm{cm^2})}{(\mathrm{yr})(\mathrm{lb_m})(\mathrm{ft^2})}$ to all SI units (6)

3. (a) The heat transfer coefficient, h for heat transfer by natural convection from a flat vertical plate depends on the length of the heated section (L), acceleration due to gravity (g), density(ρ), viscosity(μ), heat capacity(C_p), thermal conductivity (k), coefficient of

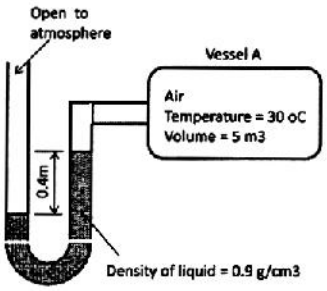
thermal expansion (β), the temperature difference between the fluid and heated plate(ΔT). Find the dimensionless form of the governing equation using Buckingham method. (16)

(b) Explain without differentiating whether the following differentiation is correct

$$\frac{d}{dx}\sqrt{1+\left(\frac{x}{a}\right)^2}=\frac{2ax}{\sqrt{1+\left(\frac{x}{a}\right)^2}}$$

where x is the length and a is a constant. (4)

4. (a) Determine the number of moles of air in vessel *A* in the figure given below, assuming air follows ideal gas law (5)



(b) Determine the value of k and n of the reaction given by the expression $r_A = kC_A^n$ using least square technique. The effect of concentration, C_A on the rate of reaction, r_A is given in the following table. (12)

C_A (kmol/m^3)	1.79x10^{-4}	2.03 x10^{-4}	2.22 x10^{-4}	2.47 x10^{-4}	2.97 x10^{-4}	3.39 x10^{-4}	4.95 x10^{-4}
r_A (kg/m^2-h)	0.28 x10^{-4}	0.32 x10^{-4}	0.36 x10^{-4}	0.4 x10^{-4}	0.49 x10^{-4}	0.59 x10^{-4}	0.99 x10^{-4}

(d) You need to concentrate a solution by removing water. Describe in brief a unit operation for the same. (3)

5. (a) A solution (100 L) contains 150 mg/L of a solute X. it is desired to reduce the concentration of X by liquid-liquid extraction. The solution is mixed with a solvent (20 L) in a

mixer (1). After separation, the raffinate is added into another mixer (2) along with fresh solvent (10 L). Determine the concentration of extraction and raffinate streams from the two mixers considering equilibrium has been attained? The ratio of the concentration of X in extract phase to that in raffinate phase at equilibrium is 5. (12)

(b) A 0.25 molar aqueous solution of sulfuric acid flows into a process unit at a rate of 1.5 m^3/min. The specific gravity of the solution is 1.05. Calculate (8)

(i) mass concentration of sulfuric acid in kg/m^3?

(ii) mass flow rate of sulfuric acid in kg/s?

(iii) mass fraction of sulfuric acid?

6. Write short notes on (a) Cox chart (b) Crystallization (c) Flow measuring devices (d) Unit operation & Unit processes (5x4)