BACHELOR OF ENGINEERING IN CHEMICAL ENGINEERING EXAMINATION, 2018

(1st Year, 1st Semester, Supplementary)

FUNDAMENTALS OF CHEMICAL ENGINEERING

Time : Three hours Full Marks : 100

(50 marks for each Part)

Use separate answer script for each part.

PART - I (50 marks)

Answer any two questions

Assume any missing data

1. (a) The diameter (*D*) of bubbles formed by a gas issuing from an orifice beneath the surface of the liquid depends on orifice diameter (*d*), density (ρ), viscosity (μ; kg/m.s), surface tension (σ; kg/s^2) and the gravitational acceleration (g). Find the dimensionless form of the governing equation using Buckingham pi theorem. (15)

   (b) The height of the crest over the weir can be estimated by the following equation $h = 0.15C(Q/L)^{0.67}$ where h is the height of the crest (in), C is the dimensionless correction factor, Q is the volumetric flow rate (L/min) and L is the length of the weir (in). Convert the equation to SI unit. (10)

2. (a) The force, F acting on spherical particles present in a flowing stream is a function of the velocity with respect to the sphere (u_r), diameter of the particle (d_p), density (ρ) and viscosity (μ) of the fluid. Obtain an expression of F in dimensionless form. (10)

   (b) The heat capacity of a substance is given by $C_p = 33.25 + 3.727\text{x}10^{-2}t$, where C_p is in cal/(gmol)(°C) and *t* is in °C. Modify the equation so that C_p is in J/(kmol)(K) and *t* is in K. (6)

   (c) Determine whether the following groups are dimensionless: (i) $\frac{C_p\mu}{K}$ (ii) $\frac{hD}{K}$ (iii) $\frac{\mu}{\rho D_v}$ (9)

   Where C_p is the heat capacity, μ is the viscosity, K is the thermal conductivity, D is diameter, D_v is the diffusion coefficient.

3. (a) Determine pressure and composition of the vapor phase in equilibrium with an equimolar binary liquid mixture of benzene and toluene at 100 °C? The following data is given

   The vapor pressure of the substances are given by (12)

$$\text{Benzene}: \log_{10} P(\text{mm Hg}) = 6.87987 - \frac{1196.76}{t(^\circ\text{C}) + 219.161}$$

$$\text{Toluene}: \log_{10} P(\text{mm Hg}) = 6.95087 - \frac{1342.31}{t(^\circ\text{C}) + 219.187}$$

   (b) Estimate the latent heat of vaporization saturated benzene at 95 °C (5)

   © Describe the different techniques for crystallization. (8)

Ex/ChE/T/113/2018(S)

B.E. CHEMICAL ENGINEERING FIRST YEAR FIRST SEMESTER SUPPLEMENTARY EXAM-2018

FUNDAMENTALS OF CHEMICAL ENGINEERING

Part-II

Use separate answer scripts for each part.

Time: Three hours *Full marks: 100*
(50 marks for each part)

*Answer any **five** questions. All questions carry equal marks. Assume any missing data.*

1 Experiments show that a ball can remain suspended in a stable position when placed in an air jet discharging vertically. The equilibrium height h of the ball in the jet is found to depend on the ball diameter D, jet diameter d, air density, ρ, air viscosity, μ, air jet speed, V and weight of the ball W. Dimensional analysis is suggested to correlate experimental data. Use Buckingham Pi theorem to obtain the Π parameters.

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2 (a) How would you measure heat of vaporization of a substance using Clausius-Clapeyron equation.
(b) How would you estimate the specific volume of a mixture of non-ideal gases?

5+5

3 Two mercury manometers, one open-end and the other sealed-end, are attached to an air duct. The reading on the open-end manometer is 25 mm and that on the sealed-end manometer is 800 mm.
Determine the absolute pressure in the duct, the gauge pressure in the duct, and the atmospheric pressure, all in mm Hg.

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4 Consider the vapor-liquid equilibrium of a two component system (B and T which are similar in chemical nature) at 75°C. For equimolar mixture of B and T in the liquid phase what is the system pressure and the composition of the vapor ?

B: $\log_{10}(\text{bar}) = 5.0768 - \frac{1659.793}{T(\text{K}) - 45.854}$

T: $\log_{10}(\text{mm Hg}) = 7.2316 - \frac{1277.03}{T(^{\circ}\text{C}) + 273.23}$

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5 (a) Write a short note on Henry's law.
(b) Discuss significance of dimensional analysis in Chemical Engineering.
(c) What is wet bulb temperature?

3+4+3

6 The Arrhenius equation which relates the rate of reaction with temperature is as follows

$$k = Ae^{-E/RT}$$

In investigating a certain chemical reaction, following data were obtained.

T(K)	k (sec^{-1})
374	3.5×10^{-16}
384	4.02×10^{-15}
391	7.5×10^{-15}
401	4.95×10^{-14}

Evaluate E and A using a semilogarithmic graph paper. $R = 8.314\ JK^{-1}mol^{-1}$

10