071

# NATIONAL INSTITUTE OF TECHNOLOGY

**Department of Chemical Engineering**

**Process Calculations (CHC 301)**

B. Tech. 3dr semester 2018-19

**Mid Term Exam**

Time: 2 hrs — Marks: 30

1. Draw the humidity chart for air water system assume all data. Label the axis properly and show all numerical data. 7.5

2. a) Prove that the shear stress ($\tau$) in a fluid flowing through a pipe can be expressed by the equation

$$\tau = \rho V^2 \Phi\left(\frac{\kappa}{D}, \frac{\mu}{\rho D V}\right)$$

Where, D = diameter of the orifice, $\mu$ = viscosity, $\rho$ = density, V = velocity
$\kappa$ = height of roughness projection **7.5**

3. a) The vapour pressure of water at 363 K and 373 K are respectively 70.11 kPa and 101.3 kPa. Estimate the mean heat of vaporization of water in this temperature range. 3

b) With one suitable example describe Hess's law. 1.5

c) One kg of water is heated from 250 K to 400 K at one standard atmosphere pressure. How much heat is required for this? The mean heat capacity of ice between 250 K and 273 K is 2.037 kJ/kg K, the mean heat capacity of water between 273 K and 373 K is 75.726 kJ/kmol K and the heat capacity of water vapour (kJ/kmol K) is
$C_P = 30.475 + 9.652 \times 10^{-3} T + 1.189 \times 10^{-6} T^2$
where T is in K. The latent heat of fusion and vaporization of water are, respectively, 6012 kJ/ kmol and 40608 kJ/kmol. 4

4. (a) How do you differentiate ideal solution and non-ideal solution? Discuss with an example.
(b) How do you calculate compressibility factor z from van der waal's equation of state? Why do we need computing z? 4+3.5

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**B. Tech. / Odd Semester Mid Term Examination (2018-2019)**
**CHEMICAL ENGINEERING THERMODYNAMICS (CH302)**
CHE302

Full Marks: **30** Time: **2 hours**

## Group A

**1. a)** An ideal gas ($C_p$ = 6 Kcal/Kmol°C, $C_v$ = 3 Kcal/Kmol°C) is changed from 1 atm and 22.4 dm³ to 10 atm and 2.24 dm³ by the following reversible process:

i) Isothermal compression

ii) Adiabatic compression followed by cooling at constant volume.

Calculate Q, W, $\Delta U$ and $\Delta H$ of the overall process in each case. 7 ½

**b)** A spherical balloon of diameter of 0.25 m containing carbon dioxide at 150 kPa is heated so that its diameter becomes 0.4 m. During the process the pressure inside is always proportional to diameter. Calculate the work done by carbon dioxide during the process of heat transmission. 5

**c)** Justify the statement with illustration – 2½

***'No change in internal energy of an ideal gas undergoing an adiabatic change'***

## Group B

***(Answer any three)***

1. (a) What is Gibbs-Duhem equation? [1]

(b) Calculate the total pressure and vapour phase mole composition when a solution of n-pentane (1) and n-heptane (2) reaches vapour-liquid equilibrium at a temperature of 68.8 °C. The liquid phase mole fraction of n-pentane (1) at the equilibrium is 0.40. Make ideal gas and ideal solution assumptions. [4]

The Antoine constants are given below.

| | *A'* | *B'* | *C'* |
|---|---|---|---|
| n-pentane (1) | 6.87632 | 1075.78 | 233.205 |
| n-heptane (2) | 6.89386 | 1264.37 | 216.640 |

2. (a) What is Gibbs' theorem to estimate partial molal property of a constituent species in an ideal gas solution? [1]

(b) A chamber with a partition contains 0.4 mole of $H_2$ and 0.3 mole of $O_2$ at 23 °C and 1 atm. The partition is suddenly removed and the gases are allowed to mix. Calculate the total change in Gibbs' free energy of the system due to mixing. Assume the system to be an ideal gas solution. [4]

3. (a) What is Gibbs free energy minimum principle? [1]

(b)The system n-pentane (1) - n-hexane (2) - n-heptane (3) forms an ideal solution. Determine the composition of the liquid which is in equilibrium with a vapour of composition $y_1$ = 0.45; $y_2$ = 0.30; $y_3$ = 0.25 at 70°C. The saturation vapour pressures at 70°C are 2129.57 Torr, 785.82 Torr and 303.99 Torr respectively. [4]

4. (a) What is Lewis Randall rule? [1]

(b). Calculate the equilibrium vapour composition for a solution containing 20 % by mole of Hydrazine in Hydrazine-water system at 393 K and 101.3 kPa. The saturation vapour pressures of Hydrazine and water at 393 K are 124.76 kPa and 199.62 kPa respectively. Use Van laar equation to estimate the activity coefficients. [4]

The Van laar constants are: A = -1.3927, B = -2.2822.

P. S[illegible]

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CHE303

**FLUID MECHANICS (CH302)**
**Mid Term Examination (2018-19)**

Full Marks: **30** Time: **2 hours**

**Group A (15 marks)**
***[Answer any four. All questions carry equal marks]***

1. [a] The lock gate of canal is rectangular, 20 m wide of 10 m high. One side is exposed to the atmosphere, the other side to water whose top surface is level with the top of the lock gate. What is the net force on the lock gate?

[b] A cylindrical oil storage tank is 60 ft deep and contains an oil of density 55lbm/ft$^3$. Its top is open to the atmosphere. What is the gauge-pressure-depth relation in this tank? What is the thickness of the tank is required?

[c] What is the density difference between two fluids is recommended for Centrifugal Decanter and why? Develop the mathematical equation for Centrifugal Decanter.

[d] A horizontal cylindrical continuous decanter is to separate 1,500 bbl/d (day) (9.93 m$^3$/h) of a liquid petroleum fraction from an equal volume of wash acid. The oil is the continuous phase and at operating temperature has a viscosity of 1.1 cP and a density of 54 lb/ft$^3$ (865 kg/m$^3$).The density of the acid is 72 lb/ft$^3$ (1,153 kg/m$^3$).Compare (a) the size of the vessel and (b)the height of the acid overflow above the vessel floor.

[e] What do you mean by fluid kinematics and briefly discuss the concept of Lagrangian and Eulerian Specifications.

**Group B (15 marks)**
***[Answer any two]***

2. (a) Deduce the velocity profile in a steady, laminar flow through a straight pipe.

(b) 100 L/min of a solution having a density of 1000 kg/m$^3$ and viscosity of $10^{-3}$ kg/m.s is to be pumped from a large reservoir to a reactor through a 30 mm ID pipe. The length of straight pipe involved is 2000 m. Discharge end is 8 m above the level of solution of reservoir and must have a pressure of 0.5 kgf/cm$^2$ (g). If a centrifugal pump of 60% is used for the purpose, estimate the power rating of the pump.

$f = 0.0014 + 0.125 / (N_{Re})^{0.32}$

**[3 + 4.5 = 7.5]**

3. (a) What is cavitation in a pump? What is NPSH of a pump?

(b) The details of the branched pipeline (Fig. 1) are furnished below.

$D_1 = 300$ mm, $D_2 = 350$ mm, $D_3 = 400$ mm
$L_1 = 200$ m, $L_2 = 300$ m, $L_3 = 400$ m
Sum of potential & Pressure heads: $H_1 = 772.3$ m, $H_2 = 420.7$ m
$f_1 = 0.0035$, $f_2 = 0.00335$, $f_3 = 0.0030$
$Q_1 = 1.988$ m$^3$/s
Find $Q_2$, $Q_3$, $H_3$.

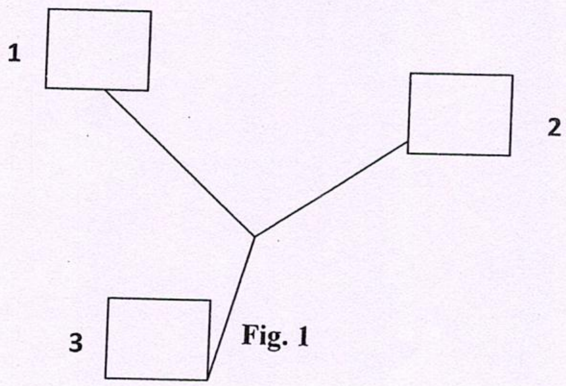

**Fig. 1**

**[1.5 + 6 = 7.5]**

4. (a) Derive the theoretical relationship between the head developed and capacity in a centrifugal pump.
(b) How do you reduce the flow fluctuation in a piston pump?
(c) Draw the structure of a multi-port ball valve.

**[5+1.5+1=7.5]**

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14.09.18
1st Half (BT)

**NATIONAL INSTITUTE OF TECHNOLOGY**
**Department of Chemical Engineering**
**Process Calculations & Thermodynamics (CHC 331)**
B. Tech. 3dr semester 2018-19
**Mid Term Exam**

Time: 2 hrs Marks: 30

1. a) An ideal gas (Cp = 6 Kcal/Kmol$^0$C, Cv = 3 Kcal/Kmol$^0$C) is changed from 1 atm and 22.4 dm$^3$ to 10 atm and 2.24 dm$^3$ by the following reversible process:

i) Isothermal compression

ii) Adiabatic compression followed by cooling at constant volume.

iii) Heating at constant volume followed by cooling at constant pressure

Calculate Q, W, ΔU and ΔH of the overall process in each case. 10

b) Show that for steady state flow process, $\Delta H = Q - W_S$

where, notations used have their usual meanings 5

2. a) The frictional pressure drop ($\Delta P$) for the flow of a fluid through a long, straight, round pipe depends upon the length (*l*), diameter (*d*), and average height of the wall roughness (*e*) of the pipe, the average fluid velocity (*u*), the density ($\rho$), and the viscosity ($\mu$) of the fluid used Buckingham-Pi method to make a dimensional analysis of the system. 8

b) An analysis of the vent gases from the chlorinator in a plant for making chlorinated rubber showed 70% by volume HCl, 20% by volume $Cl_2$ and the rest $CCl_4$

Determine the following:

(i) The percent composition by weight

(ii) The average molecular weight of the gas

(iii) The density at standard conditions (in kg/m$^3$) 3

c) One kg of water is heated from 250 K to 400 K at one standard atmosphere pressure. How much heat is required for this? The mean heat capacity of ice between 250 K and 273 K is 2.037 kJ/kg K, the mean heat capacity of water between 273 K and 373 K is 75.726 kJ/kmol K and the heat capacity of water vapour (kJ/kmol K) is

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