Paper Code: CH-302	**Roll No.**										

B TECH
THIRD SEMESTER EXAMINATION, 2016-17
CHEMICAL PROCESS CALCULATIONS

[Time: 3 Hours] [Total Marks: 100]

Note: Attempt ***ALL*** questions. Assume suitable data, if required. All question carry equal marks.

1. Attempt any ***TWO*** parts of the following: - **(10x2)**

(a) A producer gas with the composition by volume CO_2= 5.4%, CO= 27.3%,O_2= 0.6% and N_2= 66.7%, is burnt with 20% excess air. If the combustion is 98% complete, calculate the composition by volume of the flue gases.

(b) A limestone has the composition (wt%) as, $CaCO_3$ = 93%, $MgCO_3$ = 6% and insoluble = 1% , Calculate:- **(i)** How many kg of CaO will be obtained from 2000 kg of limestone? **(ii)** kg of CO_2 available per kg of limestone. **(iii)** kg of limestone required for the manufacture of 1000kg of CaO.

(c) A mixture of acetone vapour and nitrogen contains 14.8% acetone by volume. Calculate the relative saturation (Yr) and percentage saturation (Yp) of the mixture at 20°C and p= 745mm Hg. From Cox chart, we can see that vapor pressure of acetone is 184.8mm Hg at 20°C.

2. Attempt any ***TWO*** parts of the following: - **(10x2)**

(a) A furnace is fired with a natural gas that consists entirely of hydrocarbons (neglecting inert gases and sulphur compounds). The orsat analysis of the flue gas gives CO_2 = 9.5%, O_2 = 2.0% and CO = 1.8%. Calculate:-
(i) Molar ratio of net hydrogen to carbon in the fuel.
(ii) Percent of excess air is being used.

(b) Combustion gases having the following molal composition are passed into an evaporator at a temp. of 200°C and a pressure of 743 mm Hg.

CO_2 = 13.6%, O_2 = 7.2%, N_2 = 79.2%

Water is evaporated, the gases leaving at a temp. of 85°C and a pressure of 740 mm Hg with the following molal composition:

CO_2 = 8.3%, O_2 = 4.4%, N_2 = 48.3%, H_2O= 39.0%

Calculate: - **(i)** volume of gases leaves the evaporator per 100 cu ft entering. **(ii)** weight of water evaporated per 100 ft^3 of gas entering.

(c) Write short note on *"Unsteady state material balance"* in reaction system. Also explain the terms *"Purge Ratio" & "Recycle Ratio"* with the help of suitable example.

3. Attempt any ***TWO*** parts of the following: - **(10x2)**

(a) After a crystallization process, a solution of $CaCl_2$ in water contains 62 parts of $CaCl_2$ per 100 parts of water. Calculate the weight of this solution necessary to dissolve 250 kg of $CaCl_2.6H_2O$ crystals at a temperature of 25°C. Solubility of $CaCl_2$ at 25°C is 7.38 kg mol of $CaCl_2$ per 1000 kg of water.

(b) Describe the *"Enthalpy concentration chart"*. Find the relationship between molal heat capacity at constant pressure *(C_p)* and molal heat capacity at constant volume *(C_v).*

(c) For the operation of a refrigeration plant, it is desired to prepare a solution of NaCl, containing 20% by wt of anhydrous salt. Calculate:-
(i) the weight of NaCl, that should be added one gallon of water at 30°C in order to prepare this solution.
(ii) the volume of solution formed per gallon of water used, keeping the temperature at 30°C, while the specific gravity of solution is 1.15.

4. Attempt any ***TWO*** parts of the following:- **(10x2)**

(a) Ethyl ether at a temperature of 20°C, exerts a vapor pressure of 442 mm Hg. Calculate the composition of a saturated mixture of nitrogen and ether vapor at a temperature of 20°C and a pressure of 745 mm Hg, expressed in the following terms **(i)** % Composition (v/v) **(ii)** % Composition (wt/wt) **(iii)** lb of vapor per ft^3 of mixture **(iv)** lb of vapor per lb of vapor free gas **(v)** lb moles of vapor per lb mole of vapor free gas.

(b) Define "Standard heat of combustion" and "Standard heat of formation" with suitable examples.

(c) A natural gas has the following composition, all figures being in weight percent.

$$CH_4 = 70.5\%,\ CO_2 = 10.0\%,\ Ar = 2.0\%,\ N_2 = 17.5\%$$

Calculate:- **(i)** density at STP (kg/m^3) **(ii)** Average molecular weight **(iii)**Composition in vol % **(iv)** Composition in mol %

5. Attempt any ***TWO*** parts of the following:- **(10x2)**

(a) Dry methane is burned with dry air and both are initially at 25°C. The flame temperature is 1297 °C. If complete combustion is assumed, how much excess air is to be used?
Data Given:-
Heat of reaction, $\Delta H_R = -0.2 \times 10^6$ Cal
C_p for CO_2 = 12.37 Cal/mol °C
C_p for H_2O= 9.6 Cal/mol °C
C_p for N_2 = 7.68 Cal/mol °C
C_p for Air = 7.74 Cal/mol °C

(b) An approximate equation for C_p (Cal/gm mol °K) of gaseous HCL is

$$C_p = 6.6 + 0.96 \times 10^{-3}\, T$$

Calculate the heat required to raise the temperature of 1gm mol of gas from 100 to 200 °C.

(c) Define *Raoult's law*, with the help of suitable example. Calculate the density in pounds per cubic foot at 29 in. Hg and 30°C of a mixture of hydrogen and oxygen that contains 11.1% H_2 by weight.