Registration No : | | | | | | | | | | |

Total number of pages : 03 **B.Tech**
PCE3I001

3rd Semester Regular/Back Examination 2018–19
CHEMICAL PROCESS CALCULATION
BRANCH : CHEM, PT
Time : 3 Hours
Max Marks : 100
Q.CODE : E880

Answer Question No.1 (Part-I) which is compulsory, any EIGHT from Part-II, and any TWO from Part-III.
The figures in the right-hand margin indicate marks.
Assume suitable notations and any missing data wherever necessary.
Use of Humidity Chart is allowed.Answer all parts of a question at a place.

Part – I

Short Answer Type Questions (Answer AllTen)

Q1 **Answer the following questions :** **(2 x 10)**

a) Prove that: Normality= Molarity x Valency.

b) Calculate the specific gravity of CO at 300K and 101.32kPa.

c) Convert 50% by weight of diluted ethyl alcohol to mole%.

d) Differentiate between heat of mixing and heat of solution.

e) What do you mean by adiabatic flame temperature and theoretical flame temperature?

f) The specific gravity of hydrocarbon oil is 0.88 at 288 K. Calculate its value in Baume and API scales.

g) What are purging and purging ratio?

h) The vapour pressure of ethyl ether at 273 K is 25 kPa and at at 293 K is 63.5 kPa. Estimate the latent heat of vaporization of ether in kJ/kg in this temperature range.

i) The GCV of gaseous n-butane is 2880kJ/mol at 298 K. Calculate the NCV in kJ/mol and kJ/kg units using latent heat of water vapour at 298 K to be 2442.5 kJ/kg.

j) Write the objectives of bypass in an unit operation.

Part – II

Focused-Short Answer Type Questions(Answer Any Eight out of Twelve)

Q2 **Answer the following questions :** **(6 x 8)**

a) 10 kg of liquid A of specific gravity 1.2 is mixed with 3 kg of liquid B of specific gravity of 0.8. Assuming there is no volume change on mixing, find the specific gravity of the mixture.

b) "Mole fraction= pressure fraction =volume fraction".
Prove the above by considering a binary gaseous mixture of A and B.

c) An aqueous solution of Na_2CO_3 contains 15% carbonate by weight. 80% of the carbonate is recovered as $Na_2CO_3.10H_2O$ by evaporation of water and subsequent cooling to 278 K. The solubility of Na_2CO_3 at 278K is 9.0% (weight). On the basis of 100 kg of solution treated, determine:
i. the quantity of crystal formed and
ii. the amount of water evaporated.

d) The average molecular weight of a gas mixture of oxygen and sulphur dioxide is found to be 44.8. For 5 kg of this mixture at 298 K and 200 kPa, calculate:

i. the partial pressure of oxygen,
ii. the volume of the mixture, and
iii. thedensity at the standard condition.

e) Propane is burnt with excess air to ensure complete combustion. If 55 kg of CO_2 and 15 kg of CO are obtained when propane is completely burnt with 500 kg air, determine the mass of propane burnt in kg and the % excess air used.

f) Calculate the standard heat of the following reaction at 298 K:

$$C_5H_{12}(g) + 8\ O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$$

The standard heat of formation are:$CO_2(g)$ =- 394 kJ, $H_2O(g)$ =-242 kJ, and $C_5H_{12}(g)$ = -146 kJ.
The latent heat of vaporization of water at 298 K is 44 kJ/mol.

g) The wet paper pulp containing 70% water is dried in order to remove 60% of water present. Determine:

i. the mass of water removed per 100 kg of wet pulp and
ii. the composition of the dried pulp.

h) Calculate the standard heat of formation of ethane gas at 25^0C using the following data.
Heat of formation of CO_2 (g)= -393.5 kJ/mol,
Heat of formation of H_2O(l)= -285.8 kJ/mol, and
Heat of combustion of C_2H_6 (g)= -1560.7 kJ/mol.

i) Calculate the gross and net calorific values of the natural gas at 298 K having the following molar composition:
CH_4: 89.4%, C_2H_6:5%, C_3H_8:1.9%, n-C_4H_{10}:1%, CO_2:0.7%, and N_2:2%.
Data:

Component	GCV, kJ/mol	NCV, kJ/mol
CH_4	890.65	802.62
C_2H_6	1560.69	1428.64
C_3H_8	2219.17	2043.11
C_4H_{10}	2877.40	2657.32

Specific volume at 298K and 101.3 kPa=24.465 m^3/kmol.

j) Write a short note on Reference substance plots.

k) The Orsat analysis of a flue gas produced by combustion of a pure hydrocarbon fuel with an excess of dry air is found to be 8.5% CO_2, 1.0% CO, 5% O_2, and 85.5% N_2. Calculate:

i. the percent excess air used for combustion and
ii. the weight ratio of C:H in the fuel.

l) Obtain the empirical equation for calculating the heat of reaction at any temperature T (K) for the following reaction:

$$CH_4\ (g) + C_2H_6\ (g) \rightarrow C_3H_8\ (g)$$

Data :
ΔH_R^0 at 298 K = -82.66 kJ/mol,C_p^0= a +bT+ cT^2, kJ/mol.K.

Component	a	b x10^3	c x10^6
CH_4	19.2494	52.1135	11.973
C_2H_6	4.1261	155.0213	81.5455
C_3H_8	4.2227	306.264	158.6316

Part – III

Long Answer Type Questions (Answer Any Two out of Four)

Q3 Air at 303 K saturated with water vapouris dehumidified by cooling and condensation of water vapour at 286 K. Air leaving the dehumidifier saturated at 286 K is mixed with a part of original air whichis bypassed through dehumidifier. The resulting air stream is reheated to 313 K. It is desired that the final air contains water vapour not more than 0.02 kg of dry air. Calculate: **(16)**

a) the mass of dry air bypassed per each kg of dry air sent through the dehumidifier,
b) the mass of water vapour condensed in the dehumidifier per 100 $m^3$of air sent through it, and
c) the volume of final air obtained per 100 $m^3$of air passed through the dehumidifier.

Q4 The fresh feed to a methanol synthesis unit contains on mole basis: 32% CO, 64% H_2, and 4% N_2which flows at a rate of100 moles/h.The fresh feed is mixed with recycle feed flowing at a rate of 400 moles/h to produce a reactor feed containing 13 mole% N_2. The product stream leaving the condenser (after reactor)contains only liquid methanol. For preventing a build-up of nitrogen in the system, a purge stream is withdrawnfrom the gas stream leaving the condenser. The gases not purged constitute the stream recycled to the reactor. Calculate: **(16)**

a) the production rate of methanol in moles/h,
b) the molar flow rate and composition of the purge gas, and
c) the overall and single pass conversion.

Q5 A theoretical producer gas containing 35% CO and 65% N_2 at 25^0C is burnt with 50% excess air which is preheated to 200^0C. Assuming complete combustion, calculate the theoretical flame temperature. ΔH_R^0 at 298 K = -54.66 kJ/mol. **(16)**

Data:

$C_{p,O2}$ = 6.94 +0.000677 T
$C_{p,N2}$ = 6.5 +0.001413 T
$C_{p,CO}$ = 6.35+0.00018 T
$C_{p,CO2}$ = 9.1 +0.0048 T

If the products of combustion leave the reaction chamber at 500^0C, calculate the heat evolved in the reaction chamber per kmol of CO burnt for 80% conversion.

Q6 Moist air contains 0.025 kg water vapour per cubic meter of mixture at 313K and 103.15 kPa. Calculate: **(16)**

a) the relative saturation,
b) the absolute humidity of the air,
c) the percent saturation, and
d) the temperature to which the mixture be heated so that its percent saturation becomes 10%.

The vapour pressure of water (in kPa) is approximated by the Antoine equation as :

$$lnP^S = 16.262 - \frac{3799.887}{T-46.854}.$$