SE Chem (Sem III) Rev. Dec 10

Sub : Process Calculation

Con No-18

Con. 5688–10. GT–6306

(3 Hours) [Total Marks : 100

N.B. : (1) Question No. **1** is **compulsory**.
(2) Attempt any **four** questions out of remaining **six** questions.
(3) Assumptions made should be **clearly** stated.
(4) Assume any **suitable** data wherever **required** and **justify** the same.
(5) **Figures** to the **right** indicate marks.

Q. 1) A) Calculate the energy required to dissociate a kilogram of sodium bicarbonate at 298 K:-

$$2NaHCO_{3\,(s)} \rightarrow Na_2CO_{3\,(s)} + CO_{2\,(g)} + H_2O_{(g)} \qquad \textbf{(06)}$$

Component	ΔH^0_f, kJ/mol at 298 K
$NaHCO_{3\,(s)}$	-950.81
$Na_2CO_{3\,(s)}$	-1130.68
$CO_{2\,(g)}$	-393.51
$H_2O_{(g)}$	-241.82

B) The GHV of butane is 2877.40 kJ/mol at 298 K. Calculate its NHV in kJ/mol ans kJ/kg. Latent heat of water vapor at 298 K=2442.5 kJ/kg. **(06)**

C) A wet pulp is found to contain 71% water. After drying it is found that 60% of the original water has been removed. Calculate a) composition of dry pulp, b) mass of water removed per kg of dry pulp. **(08)**

Q. 2) A) A solution contains 40 % ammonium nitrate, 20 % urea and KCl in water. Calculate available nitrogen content in solution. **(08)**

B) A multiple effect evaporator system has a capacity of processing 1000 kg per day of solid caustic soda. When it concentrates weak liquor from 4% to 25% (wt basis), when the same plant is fed with 10% weak liquor and concentrated to 50%. Find the capacity of plant in terms of solid caustic soda, assuming water evaporation capacity will be same in both cases. **(12)**

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Q. 3) A) The crystallizer is fed with a saturated solution of $MgSO_4$ at 353 K. The mass is cooled to 303 K to obtain $MgSO_4.7H_2O$ crystals. During cooling 4% solution is lost by evaporation of H_2O. Calculate the quantity of saturated solution that should be fed to the crystallizer in order to obtain 1000 kg of MgSO4.7H2O crystals.

Data:- solubility of $MgSO_4$ in H2O at 353 K = 64.2 kg $MgSO_4$/100 kg H_2O **(10)**

solubility of $MgSO_4$ in H_2O at 303 K= 40.8 kg $MgSO_4$/100 kg H_2O

B) Carbon monoxide and steam are fed to a reactor for production of hydrogen and carbon dioxide. The product gas is found to contain 38.46 mole % H_2, 38.46 mole % CO_2 and 23.08 mole % H_2O. Find the mole ratio of steam to carbon monoxide. **(10)**

Q.4) A) Benzene and toluene are to be seerated by distillation. The feed contains 45% by wt benzene. The overhead product contains 98% benzene by wt and the bottom product contains 8% of the total benzene fed to the distillation column. Find the overhead product rate in kg/h and total composition in bottom product, if feed rate is 2000 kg/h. **(10)**

B) A gas stream containing 65 mole % ethane and 35 mole % butane is fed to a combustion chamber where it is oxidized to CO_2 and H_2O. air is supplied 20% excess of that theoretically required. Calculate the amount of gas leaving the chamber per 100 kg of gas fed assuming complete combustion. **(10)**

Q.5) A) A natural gas has the following composition on mole basis:-

CH_4=84%, C_2H_6=13%. N_2=3%. Calculate the heat to be added to heat 10 kmol of natural gas from 298 K to 523 K using the heat capacity data given below:-

Data:- $Cp^0=a+bT+cT^2+dT^3$ kJ/(kmol.K) **(10)**

Gas	a	$b * 10^3$	$c * 10^6$	$d * 10^9$
CH_4	19.2494	52.1135	11.973	-11.3173
C_2H_6	5.4129	178.0872	-67.3749	8.7147
N_2	29.5909	-5.141	13.1829	-4.968

B) A sample of fuel oil has C/H ratio 9.33 by wt. it contains 1.3 % sulphur by wt. the NVC of oil is 39685 kJ/kg at 298 K. Calculate the GCV using latent heat of water at 298 K as 2442.5 kJ/kg. **(10)**

Q.6) A) In synthesis of methanol, fresh feed containing 32% CO, 64% H_2 and 4% inerts (by volume) is mixed with recycle feed. Mixed feed entering the reactor results in 20% per pass conversion of CO. the product stream from reactor is fed to condenser where all methanol formed getd condensed and the gases from condenser are recycled. In order to prevent build up of inerts in recycle loop, a small portion of gases leaving the condenser is continuously purged. If missed feed contains 15 mole % inerts, calculate:-

a) recycle ratio, b) purge ratio. **(15)**

B) Write short note on:-

a) recycle ratio, b) combined feed ratio, c) purge ratio **(05)**

Q.7) A) Write short notes on: - **(12)**

Normality, Hess's law, Conversion, Recycle ratio, Orsat analysis, NCV

B) Prove for ideal gas:- Pressure %= Mole %= Volume % . **(08)**