P P SAVANI UNIVERSITY

Third Semester of B. Tech. Examination

May 2019

SECH2010 Chemical Process Calculations

18.05.2019, Saturday **Time: 09:00 a.m. To 11:30 a.m.** **Maximum Marks: 60**

Instructions:

1. The question paper comprises of two sections.
2. Section I and II must be attempted in separate answer sheets.
3. Make suitable assumptions and draw neat figures wherever required.
4. Use of scientific calculator is allowed.
5. Atomic weight: Na=23, N=14, O=16, C=12, H=1, S=32, Cl=35.5, K=39, Mg-24, Zn-65, Al-27, B-10, Si-28.

SECTION – I

Q - 1 **Answer the following: (Any Five)** **[05]**

(i) Explain the concept of unit operation and unit process.

(ii) Define: Latent heat

(iii) What do you mean by vapour pressure?

(iv) Define: Tie material

(v) What is the role of inerts in establishing mole balance?

(vi) Explain the concept of limiting and excess reactant.

(vii) Draw a block diagram of recycle operation.

Q - 2 (a) In a textile mill, a double effect evaporator system concentrates weak liquor containing 4% (by weight) caustic soda to produce a lye containing 25% solids (by weight).Calculate the evaporation of water per 100 kg feed in the evaporator. **[05]**

Q - 2 (b) Calculate the heat of reaction of the following reaction. **[05]**

$4NH_3(g) + 5O_2(g) \Rightarrow 4NO(g) + 6H_2O(g)$

Data:

Component	$\Delta H_f°$ cal/gmol
$NH_{3\,(g)}$	-11020
$NO_{(g)}$	21570
$H_2O_{(g)}$	-57796

OR

Q - 2 (a) Soybean seeds are extracted with hexane in batch extractors. The flecked seeds contain 18.6% oil, 69.0% solids & 12.4% moisture cake. At the end of the extraction process the cake is separated from the hexane oil mixture. The cake analysis yields, 0.8% oil, 87.8% solids and 11.5% moisture. Find the% recovery of oil .All percentage is on wt. basis. **[05]**

Q - 2 (b) It is required to make 1000 kg mixed acid containing 60% H_2SO_4, 32% HNO_3 and 8% water by blending (i) the spent acid containing 11.3% HNO_3, 44.4% H_2SO_4 and 44.3% H_2O. (ii) Aqueous 90% HNO_3 and (iii) aqueous 98% H_2SO_4. All percentages are by weight. Calculate the quantities of each of the three acids required for blending. **[05]**

Q - 3 (a) For carrying out nitration reaction, it is desired to have a mixed acid containing 39% HNO_3, 42% H_2SO_4 (by mass). Nitric acid of 68.3% (by mass) is readily available. Calculate: (a) the required strength of sulphuric acid to obtain the above mixed acid and (b) the mass ratio of nitric acid to sulphuric acid to be mixed. **[05]**

Q - 3 (b) Discuss methods of solving material balance problems without chemical reaction. **[05]**

OR

Q - 3 (a) A distillation column separates 10000 kg/hr of a 50% benzene-50% toluene mixture. The product D recovered from the condenser at the top of the column contains 95% benzene, **[05]**

and the bottom W from the column contains 96% toluene. The vapor stream V entering the condenser from the top of the column is 8000 kg/hr. A portion of the product from the condenser is returned to the column as reflux, and the rest is withdrawn for use elsewhere. Assumes that the compositions of the streams at the top of the column (V), the product withdrawn (D), and the reflux (R) are identical because the V stream is condensed completely. Find the ratio of the amount refluxed (R) to the product withdrawn (D).

Q - 3 (b) Discuss about recycling and by passing operations. **[05]**

Q - 4 **Attempt any one.** **[05]**

(i) In the Deacon process for manufacturing chlorine, hydrochloric acid gas is oxidized with air. The reaction taking place is: $4HCl + O_2 = 2Cl_2 + 2H_2O$ If the air is used in excess of 30% of that theoretically required and if the oxidation is 80% complete, calculate the composition by volume of dry gases leaving the reaction chamber.

(ii) Tallow is essential glyceryl tristearate. It is desired to seponify the tallow with caustic soda. For 100 kg of tallow, calculate (a) the theoretical requirement of caustic soda, and (b) the amount of glycerin liberated. Data Given: Molecular weight of glyceryl tristearate = 890 kg/kgmol Molecular weight of caustic soda = 40 kg/kgmol Molecular weight of sodium stearate = 306 kg/kgmol Molecular weight of glycerin = 92 kg/kgmol

SECTION – II

Q - 1 **Answer the following (Any Five)** **[05]**

(i) Explain Super saturation.

(ii) What do you mean by solubility of gases?

(iii) Define: Heats of formation

(iv) Define: Degrees of freedom in steady-state processes.

(v) Define: Combustion

(vi) What do you mean by purge operation?

(vii) State Hess's Law.

Q - 2 (a) Vapour phase oxidation of ethyl alcohol using Copper catalyst at 550°C produces acetaldehyde by the following reaction: $C_2H_5OH + 0.5\ O_2 \leftrightarrow CH_3CHO + H_2O$. The conversion is 30% and excess air supplied is 10%. Calculate the composition of product stream if 100kg of C_2H_5OH per hour is fed to the reactor. **[05]**

Q - 2 (b) Pure methane is completely burned with air in a combustor. The outlet gas from the combustor is passed through a cooler where some of the moisture is removed. The gas leaving the cooler contains 0.8335 mol. fraction of Nitrogen. The combustion reaction taking place is: $CH_4 + 2O_2 \leftrightarrow CO_2 + 2\ H_2O$. Calculate: (i) analysis of gas leaving the cooler (ii) weight of water condensed per mole of methane burnt. **[05]**

OR

Q - 2 (a) A stream of carbon dioxide flowing at a rate of 100 kmol/min is heated from 298 K to 383 K. Calculate the heat that must be transferred using C°_p. Data: $C^\circ_p = a + bT + cT^2 + dT^3$, kJ/(kmol. K) **[05]**

Gas	a	b x 10^3	c x 10^6	d x 10^9
Liquid	21.3655	64.2841	-41.0506	9.7999

Q - 2 (b) Crude oil is found to contain 87.1% carbon, 12.5% hydrogen and 0.4% sulphur (by mass). Its GCV at 25°C is measured to be 45071 kJ/kg oil. Calculate its NCV at 25°C. Latent heat of water vapor at 25°C = 2442.5 kJ/kg. **[05]**

Q - 3 (a) A mixture of aniline and water containing 11.8% by weight of aniline is cooled from 100 °C to 40 °C with the help of cooling water. Find the amount of heat removed by cooling 100 kg of aniline mixture. The specific heat $Cp = a + bT + cT^2$ (kcal/kg °C) where constants a, b, c are: For aniline: a= 1.407, b= 2.467 X 10^{-3}, c= -6.08 X 10^{-6}
For water: a= 0.6741, b= 2.8 X 10^{-3}, c= 8.3 X 10^{-6} **[05]**

Q - 3 (b)	Explain: Watson, Riedel Equation, Antoine Equation, NIST equation	[05]

OR

Q - 3 (a)	15000 kg/day of a mixture containing methyl ethyl ketone (MEK) and butanol is to be separated into top product containing 99.5 mole% MEK. The bottom product should not contain more than 1% of MEK. Feed mixture contains 68 mole % of MEK. If 475 kmoles of vapor/day are leaving the column, calculate: (i) top and bottom product obtained per day, (ii) reflux ratio. Data: Mol. Wt. of MEK = 72 and butanol = 74	**[05]**
Q - 3 (b)	Describe the classification of fuels.	**[05]**
Q - 4	**Attempt any one.**	**[05]**
(i)	The dry bulb temperature and dew point of ambient air were found to be 302K (29 °C) and 291K (18°C) respectively. The barometer records 100 kPa a (750torr). Compute (a) the absolute molal humidity (b) the absolute humidity (c) the % RH (d) the % saturation (e) the humid heat and (f) the humid volume.	
(ii)	Discuss proximate analysis and ultimate analysis of coal.	

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