Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III (NEW) EXAMINATION – WINTER 2023

Subject Code:3130508 Date:25-01-2024

Subject Name:Material & Energy Balance Computation

Time:10:30 AM TO 01:00 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**
5. **Atomic mass Na = 23, S = 32, Cl = 35.5, N = 14**

Q.1	**(a)**	Define Normality, Molarity & Molality.	**03**
	(b)	In double effect evaporator plant the second effect is maintain under the vacuum of 475torr (mmHg). Find the absolute pressure in kgf/cm^2, atm, kPa, bar.	**04**
	(c)	Explain importance of process flow sheet in Chemical Engineering Industry with atypical example.	**07**
Q.2	**(a)**	Define: standard heat of reaction, standard heat of formation and standard of heat of combustion.	**03**
	(b)	Define: (a) Yield (b) Selectivity (c) Limiting reactant (d) Excess reactant.	**04**
	(c)	An aqueous solution of acetic acid of 35% concentration (by mass) has density 1.04 kg/l at 298.15 K. Find thenormality, molarity and molality of the solution.	**07**
		OR	
	(c)	Sodium chloride weighing 350 kg is mixed with 550 kg potassium chloride. Calculate the composition of the mixture in (i) weight % (ii) mol%.	**07**
Q.3	**(a)**	How many moles of H_2SO_4 will contain 64 kg of S?	**03**
	(b)	In production of Sulphur trioxide, 100 kmol of SO_2 and 100 kmol of O_2 are fed to a reactor. The product stream is found to contain 80 kmol SO_3. Find the percent conversion of SO_3.	**04**
	(c)	2000 kg of wet solids containing 70% solids by weight are fed to a tray dryer where it is dried by hot air. The product finally obtained is found to contain 1% moisture by weight, calculate: (a) the kg of water removed from solids, (b) the kg of product obtained.	**07**
		OR	
Q.3	**(a)**	Explain Ideal gas law, Dalton's law and Raoult's law.	**03**
	(b)	Estimate the consumption of ammonia and air for production of 2000 kg of nitric acid per hour. The yield of NO is 97%, the yield of HNO_3 is 92% and the content of NH_3 in the dry NH_3-air mixture is 7% by weight.	**04**
	(c)	The dilute acid containing 20% H_2SO_4 is concentrated by commercial grade sulphuric acid containing 98% $H_2SO_4$to obtain desired acid containing 65% H_2SO_4. Find the quantities of the acids required to make 1000 kg of desired acid.	**07**

Q.4 **(a)** Explain importance of material and energy balance computations in chemical engineering. **03**

(b) Calculate the heat needed to raise the temperature of 1 kmol of ammonia from 311 K to 415 K using the mean molal heat capacity. **04**

Data:

C°_{pm} for NH_3 between 311 K and 298 K = 35.8641 kJ/(kmol.K)

C°_{pm} for NH_3 between 415 K and 298K = 37.7063kJ/(kmol.K)

(c) In the Decon process for the manufacture of chlorine, a dry mixture of hydrochloric acid gas and air is passed over a heated catalyst which promotes oxidation of acid. Air is used 30% excess of that theoretically required. Calculate the weight of air supplied per kilogram of the acid. **07**
(Atomic weight of Air contains 23.2% O_2 by weight)

OR

Q.4 **(a)** Give classification of fuel in brief. **03**

(b) Define: (a) Latent heat of vaporization (b) Latent heat of fusion (c) Latent heat of sublimation (d) Sensible heat. **04**

(c) In manufacture of chlorine, feed containing hydrochloric acid gas and air are fed to an oxidizer. The product gases leaving the oxidizer are found to contain 13.2% HCl, 7.6 % O_2, 42.9% N_2, 30% Cl_2 and 6.3% H_2O (by weight). Calculate: **07**

(a) the percent excess air used,
(b) the composition by weight of gases entering the oxidizer,
(c) the degree of completion of oxidation.

Q.5 **(a)** Discuss general energy balance procedure. **03**

(b) Obtain an empirical equation for calculating the heat of reaction at any temperature T (in K) for the following reaction: **04**

$CH_{4(g)} + C_2H_{4(g)} \rightarrow C_3H_{8(g)}$

Data:

ΔH°_R at 298 K (25˚C) = -85. 70 kJ/mol

$C^{\circ}_P = a + bT + cT^2 + dT^3$ kJ/(kmol.K) or J/(mol.K)

Component	a	b * 10^3	c * 10^6	d * 10^9
CH_4	19.2494	52.1135	11.973	-11.3173
C_2H_4	4.1261	155.0213	81.5455	16.9755
C_3H_8	-4.2227	306.264	-158.6316	32.1455

(c) Define GCV and NCV for fuels and its importance. List out the equipment's used for measuring CV of solid, liquid and gases. **07**

OR

Q.5 **(a)** State Hess's law **03**

(b) Methane gas is heated from 303 K to 503 K at atmospheric pressure. Calculate the heat added per kmol methane using C°_P data given below. **04**

Data: $C^{\circ}_P = a + bT + cT^2 + dT^3$

Gas	a	b * 10^3	c * 10^6	d * 10^9
Methane	19.2494	52.1135	11.973	-11.3173

(c) Discuss Proximate and Ultimate analysis of coal. **07**

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