

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<sup>2</sup>, 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<sub>2</sub>SO<sub>4</sub> will contain 64 kg of S? **03**  
(b) In production of Sulphur trioxide, 100 kmol of SO<sub>2</sub> and 100 kmol of O<sub>2</sub> are fed to a reactor. The product stream is found to contain 80 kmol SO<sub>3</sub>. Find the percent conversion of SO<sub>3</sub>. **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: **07**  
(a) the kg of water removed from solids,  
(b) the kg of product obtained.

**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<sub>3</sub> is 92% and the content of NH<sub>3</sub> in the dry NH<sub>3</sub>-air mixture is 7% by weight. **04**  
(c) The dilute acid containing 20% H<sub>2</sub>SO<sub>4</sub> is concentrated by commercial grade sulphuric acid containing 98% H<sub>2</sub>SO<sub>4</sub> to obtain desired acid containing 65% H<sub>2</sub>SO<sub>4</sub>. 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**

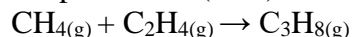
(a) the percent excess air used,

(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**



Data:

$\Delta H_R$  at 298 K (25°C) = -85.70 kJ/mol

$C_P = a + bT + cT^2 + dT^3$  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:  $C_P = a + bT + cT^2 + dT^3$

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

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

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