

Seat No.: _____

Enrolment No. _____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– III (New) EXAMINATION – WINTER 2019

Subject Code: 3130508

Date: 3/12/2019

Subject Name: Material & Energy Balance Computation

Time: 02:30 PM TO 05:00 PM

Total Marks: 70

Instructions:

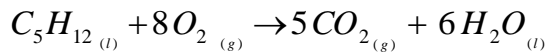
1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

	Marks
Q.1 (a) A mixture of nitrogen and carbon dioxide at 298 K and 101.325 kPa has an average molecular weight of 31. Calculate the partial pressure of nitrogen.	03
(b) The flow rate of water through a pipe is reported as 20 ft ³ / min. Convert the volumetric flow rate into the mass flow rate in kg/sec. Density of water is 1 gm/cc.	04
(c) Discuss the importance of recycling and bypassing operation	07
Q.2 (a) A sample of well water contains 140 gm/m ³ Ca ⁺ ions and 345 gm/m ³ Na ⁺ ions. Express the hardness of the water sample in terms of equivalent of CaCO ₃ in gm/m ³ . (Atomic weight of Ca = 40, Na = 23, C = 12 and O = 16)	03
(b) Describe the material balance of drying operation.	04
(c) A solution of NaCl in water contains 15 % NaCl (by mass) at 335 K. The density of the solution is 1.127 kg/lit. Determine the molarity, normality and molality of the solution.	07
OR	
(c) A gaseous mixture has the following composition by volume. SO ₂ = 6 %, O ₂ = 9%, CO = 1.5% and CO ₂ = 4.5 % and remaining is nitrogen. Calculate (a) the density of gas mixture at a temperature of 425 K and at a pressure of 202.65 kPa g and (b) Composition by weight.	07
Q.3 (a) Describe the material balance of liquid – liquid extraction.	03
(b) In a paper mill, a wash liquor containing 3% (by weight) solid is concentrated in an evaporator to yield a lye containing 30% (by weight) solids. Calculate the quantity of water evaporated per 100 kg of feed?	04
(c) A coke is known to contain 90% carbon and 10% non combustible ash by weight. (a) Calculate the moles of oxygen are theoretically required to burn 100 kg of coke completely? (b) If 50 % excess air is supplied calculate the analysis of gases at the end of combustion.	07

OR

- Q.3 (a)** List out the classification of material balance problems. **03**
- (b)** The orsat analysis of a flue gas is $\text{CO}_2 = 12.7\%$, $\text{O}_2 = 7.1\%$, $\text{N}_2 = 80.2\%$. Determine the percentage excess air used in combustion. The nitrogen present in the flue gas is contributed by air only. **04**
- (c)** In a production of chlorine gas by oxidation of hydrochloric acid gas, air is used 30 % in excess of that theoretically required. Based on 4 kmol HCl, Calculate; (a) The weight ratio of air to HCl gas in feed. (b) If oxidation is 85 % complete, calculate the composition of product stream on mole basis. **07**

- Q.4 (a)** Calculate the standard heat of reaction of the following reaction using std. heat of formation data. **03**



Component	$\Delta H_f^0 = \text{kJ/mol @ } 25^\circ\text{C}$
$\text{C}_5\text{H}_{12(l)}$	-173.49
$\text{CO}_{2(g)}$	-393.51
$\text{H}_2\text{O}_{(l)}$	-285.83

- (b)** A feed to a continuous fractionating column (Distillation column) analyses by weight 28 % benzene and 72 % toluene. The analysis of the distillation shows 52 % (weight) benzene and 5 % (weight) benzene was found in the bottom product. Calculate the amount of distillation and bottom product per 1000 kg of feed per hour. Also calculate the recovery of benzene. **04**
- (c)** Pure CO is mixed with 100 % excess air and burnt. Only 80% of CO is burns. The reactants are at 100 °C and the products are at 300 °C. Estimate the amount of heat added or removed per kmol of CO fed to the reactor. **Data:** Mean molal specific heat between 25 °C and T °C in kJ/kmol K are as follows. **07**

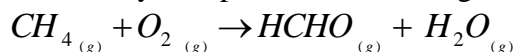
Gas	T = 100 °C	T = 300 °C
CO	29.22	30.61
CO ₂	-	43.77
O ₂	29.64	43.77
N ₂	29.17	29.66

Standard heat of formation at 25 °C are:

CO = -110524 kJ/kmol and CO₂ = -393514 kJ/kmol

OR

- Q.4 (a)** Calculate the enthalpy change (std. heat of reaction) between reactants and products if both are at 298.15 K and if 10 mol of formaldehyde is produced according to the following reaction. **03**



Component	$\Delta H_c^0 = \text{kJ/mol @ } 25^\circ\text{C}$
$\text{CH}_4(g)$	-890.65
HCHO	-563.46

- (b)** The spent acid from a nitrating process contains 15% HNO₃, 65% H₂SO₄ and 20% H₂O by weight. This acid is to be concentrated to contain 25 % HNO₃ and 58 % H₂SO₄ by addition of concentrated sulphuric acid containing 93% H₂SO₄ and concentrated nitric acid **04**

containing 90% HNO₃. Calculate the weights of spent acid, concentrated sulphuric acid and concentrated nitric acid that must be combined to obtain 100 kg of the desired mixture.

- (c) A gas mixture has the following composition on mole basis. CH₄ = 84, C₂H₆ = 13% and N₂ = 3%. Calculate the energy to be added to heat the 15 kmol of gas mixture from 298 K to 523 K using heat capacity data given below.
 $C_p^0 = a + bT + cT^2 + dT^3$
 where C_p^0 is in kJ/kmol K or J/mol K

Component	a	b x 10 ³	c x 10 ⁶	d x 10 ⁹
CH ₄ (g)	19.25	52.11	11.97	- 11.32
C ₂ H ₆ (g)	5.41	178.19	- 67.38	8.72
N ₂ (g)	29.59	- 5.41	13.18	- 4.97

- Q.5 (a) Define. (a) Adiabatic flame temperature (2) Latent heat (c) Excess air requirement. **03**
- (b) A liquid fuel is found to contain 83% C, 15% hydrogen and 2% Sulphur. Calculate the net calorific value (NCV) of liquid sample at 298 K. **04**
Data: Gross calorific value of fuel at 298 K is 45071 kJ/kg of liq fuel.
 Latent heat of water vapour at 298K =2442.5 kJ/kg.
- (c) Discuss classification of fuels and define calorific values of fuels. **07**

OR

- Q.5 (a) Define. (1) Heat capacity (2) Calorie (3) Humidity **03**
- (b) Calculate the calorific value at 298K of a sample of fuel oil having C/H ratio of 9.33 (by weight) and containing sulphur to the extent of 1.3 % by weight. **04**
Data:
 The Gross calorific value (GCV) of fuel oil at 298 K = 41785 kJ/kg.
 Latent heat of water vapour (25 °C) = 2442.5 kJ/kg
- (c) Discuss Ultimate analysis and proximate analysis of coal. **07**
