

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:

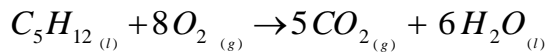
1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

	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? 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.	04
(c)	07

OR

- Q.3** (a) List out the classification of material balance problems. **03**
 (b) The orsat analysis of a flue gas is CO₂ = 12.7 %, O₂ = 7.1% N₂ = 80.2 %. Determine the percentage excess air used in combustion. **04**
 The nitrogen present in the flue gas is contributed by air only.
 (c) In a production of chlorine gas by oxidation of hydrochloric acid gas, **07**
 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 off product stream on mole basis.

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



Component	$\Delta H_f^0 = \text{kJ/mol @25}^\circ\text{C}$
C ₅ H ₁₂ (l)	-173.49
CO ₂ (g)	-393.51
H ₂ O (l)	-285.83

- (b) A feed to a continuous fractionating column (Distillation column) **04**
 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.
 (c) Pure CO is mixed with 100 % excess air and burnt. Only 80% of CO **07**
 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.

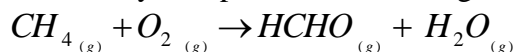
Gas	T = 100 °C	T = 300 °C
CO	29.22	30.61
CO ₂	-	43.77
O ₂	29.64	43.77
N ₂	29.17	29.66

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 **03**
 reactants and products if both are at 298.15 K and if 10 mol of formaldehyde is produced according to the following reaction.



Component	$\Delta H_c^0 = \text{kJ/mol @25}^\circ\text{C}$
CH ₄ (g)	-890.65
HCHO	-563.46

- (b) The spent acid from a nitrating process contains 15% HNO₃, 65% **04**
 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

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. **07**
- $$C_p^0 = a + bT + cT^2 + dT^3$$
- where C_p⁰ 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**
