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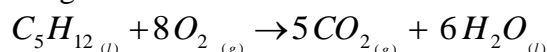
**GUJARAT TECHNOLOGICAL UNIVERSITY****BE - SEMESTER– III (New) EXAMINATION – WINTER 2019****Subject Code: 3130508****Date: 3/12/2019****Subject Name: Material & Energy Balance Computation****Time: 02:30 PM TO 05:00 PM****Total Marks: 70****Instructions:**

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

		Marks
<b>Q.1</b>	(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.	<b>03</b>
	(b) The flow rate of water through a pipe is reported as 20 ft <sup>3</sup> / min. Convert the volumetric flow rate into the mass flow rate in kg/sec. Density of water is 1 gm/cc.	<b>04</b>
	(c) Discuss the importance of recycling and bypassing operation	<b>07</b>
<b>Q.2</b>	(a) A sample of well water contains 140 gm/m <sup>3</sup> Ca <sup>+</sup> ions and 345 gm/m <sup>3</sup> Na <sup>+</sup> ions. Express the hardness of the water sample in terms of equivalent of CaCO <sub>3</sub> in gm/m <sup>3</sup> . (Atomic weight of Ca = 40, Na = 23, C = 12 and O = 16)	<b>03</b>
	(b) Describe the material balance of drying operation.	<b>04</b>
	(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.	<b>07</b>
	<b>OR</b>	
	(c) A gaseous mixture has the following composition by volume. SO <sub>2</sub> = 6 %, O <sub>2</sub> = 9%, CO = 1.5% and CO <sub>2</sub> = 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.	<b>07</b>
<b>Q.3</b>	(a) Describe the material balance of liquid – liquid extraction.	<b>03</b>
	(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.	<b>04</b>
		<b>07</b>

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. **07**  
 (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 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  $100^\circ\text{C}$  and the products are at  $300^\circ\text{C}$ . Estimate the amount of heat added or removed per kmol of CO fed to the reactor. **Data:** Mean molal specific heat between  $25^\circ\text{C}$  and  $T^\circ\text{C}$  in kJ/kmol K are as follows. **07**

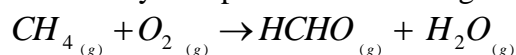
Gas	$T = 100^\circ\text{C}$	$T = 300^\circ\text{C}$
CO	29.22	30.61
$\text{CO}_2$	-	43.77
$\text{O}_2$	29.64	43.77
$\text{N}_2$	29.17	29.66

Standard heat of formation at  $25^\circ\text{C}$  are:

CO = -110524 kJ/kmol and  $\text{CO}_2 = -393514$  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%  $\text{HNO}_3$ , 65%  $\text{H}_2\text{SO}_4$  and 20%  $\text{H}_2\text{O}$  by weight. This acid is to be concentrated to contain 25 %  $\text{HNO}_3$  and 58 %  $\text{H}_2\text{SO}_4$  by addition of concentrated sulphuric acid containing 93%  $\text{H}_2\text{SO}_4$  and concentrated nitric acid **04**

containing 90%  $\text{HNO}_3$ . 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.  $\text{CH}_4 = 84$ ,  $\text{C}_2\text{H}_6 = 13\%$  and  $\text{N}_2 = 3\%$ . 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 <sup>3</sup>	c x 10 <sup>6</sup>	d x 10 <sup>9</sup>
$\text{CH}_4$ (g)	19.25	52.11	11.97	- 11.32
$\text{C}_2\text{H}_6$ (g)	5.41	178.19	- 67.38	8.72
$\text{N}_2$ (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**

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