

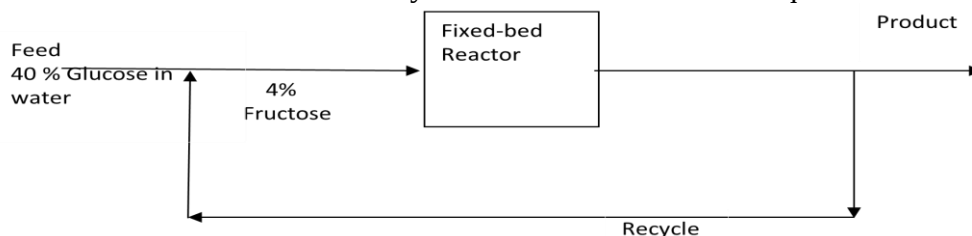
GUJARAT TECHNOLOGICAL UNIVERSITY**BE - SEMESTER-VI • EXAMINATION – WINTER • 2014****Subject Code: 163502****Date: 28-11-2014****Subject Name: Material and Energy Balance Calculations****Time: 02:30 pm - 05:00 pm****Total Marks: 70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.
4. Atomic weight: H:1, C:12, N:14, O:16, S:32, Cu=63.5.

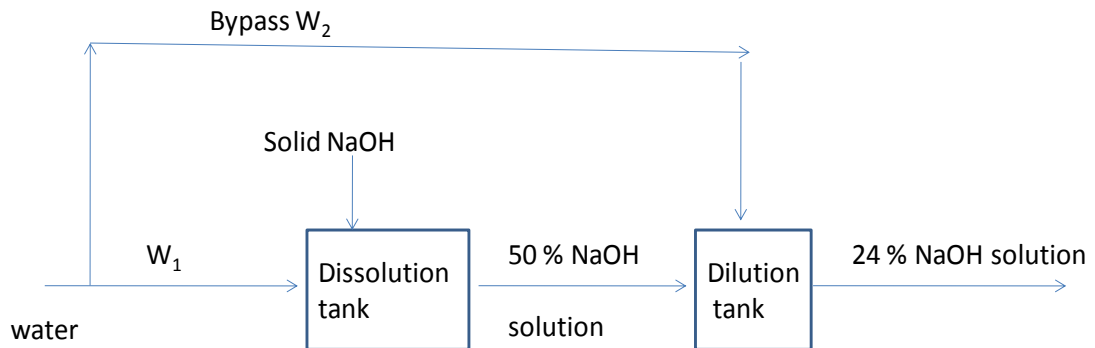
- Q.1 (a)** The thermal conductivity of an insulating brick is 0.15 BTU/ (ft h °F). Express the thermal conductivity in SI units. **07**
- (b)** The gaseous reaction $A = 2B + C$ takes place isothermally in a constant- pressure reactor. Starting with a mixture of 75 % A and 25 % inerts (by volume), in a specified time the volume double. Calculate the conversion achieved. **07**
- Q.2 (a)** The average molecular weight of the flue gas sample is calculated by two different engineers. One engineer used the correct molecular weight of N_2 as 28, while the other used an incorrect value of 14. They got the average molecular weight as 30 and the incorrect one as 18.74. Calculate the % volume of N_2 in the flue gases. If the remaining gases are CO_2 and O_2 , calculated their compositions also. **07**
- (b)** Define the following terms **07**
- (1) Limiting component
 - (2) Yield
 - (3) selectivity,
 - (4) Overall conversion,
 - (5) Molality,
 - (6) Molality
 - (7) Normality.

OR

- (b)** Immobilized glucose isomerase is used as a catalyst in producing fructose from glucose in a fixed-bed reactor (water is the solvent). For the system shown in figure, what percent conversion of glucose results on one pass through the reactor when the ratio of the exit stream to the recycle stream in mass units is equal to 8.33 ? **07**



- Q.3 (a)** In a textile industry, it is desired to make a 24 % solution (by mass) of caustic soda for a mercerisation process. Due to the very high heat of dissolution of caustic soda in water, the above solution is prepared by a two-step process. **07**
- First, in a dissolution tank, caustic soda is dissolved in the correct quantity of water to produce 50 % (by mass) solution. After complete dissolution and cooling, the solution is taken to dilute tank where some water is added to produce 24 % solution. The two step process is shown in figure. Find out W_1/W_2 .



- (b) A weight of 1.10 kg of Carbon dioxide occupies a volume of 33 liter at 300 K. Using the Van der Waals equation of state, calculate the pressure. Data: For CO₂, take $a = 3.60[(\text{m}^3)^2\text{-kPa}]/(\text{kmol})^2$ and $b = 4.3 \times 10^{-2} \text{ m}^3/\text{kmol}$. 07

OR

- Q.3 (a) In an electrochemical cell, the current is passed at the rate of 1130 A for 18000 s through a solution containing copper sulphate. At the end of the process, 1.12 m³ of oxygen (at NTP) is collected. Find (a) amount of copper liberated (b) the current efficiency of the cell. 07
- (b) Soil contaminated with polyaromatic hydrocarbons can be treated with hot air and steam to drive out contaminants. If 30 m³ of air at 100 °C and 98.6 kPa with a dew point of 30 °C are introduced into the soil, and in soil the gas cools to 14 °C at a pressure of 109.1 kPa, what fraction of the water in the gas at 100 °C condenses out in the soil? Vapour pressure of water at 30 °C and 14 °C are 4.24 kPa and 1.60 kPa respectively. 07
- Q.4 (a) A heat exchanger for cooling a hot hydrocarbon liquid uses 10000 kg/h of cooling water, which enters the exchanger at 294 K. The hot oil at the rate of 5000 kg/h enters at 423 K and leaves at 338 K and has an average heat capacity of 2.5 kJ/kg K. Calculate the outlet temperature of water. 07
- (b) Pure methane is heated from 303 K to 523 K at atmospheric pressure. Calculate the heat added per kmol methane using the following data: 07

$$C_p = 19.2494 + 52.1135 \times 10^{-3}T + 11.973 \times 10^{-6}T^2 - 11.317 \times 10^{-9}T^3 \text{ KJ}/(\text{kmolK})$$

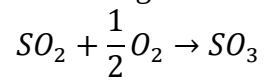
OR

- Q.4 (a) The molal heat capacity of CO is given by 07
- $$C_p = 26.586 + 7.582 \times 10^{-3}T - 1.12 \times 10^{-6}T^2 \text{ KJ}/(\text{kmolK})$$
- Calculate the mean molal heat capacity in the temperature range of 500-1000 K.
- (b) The vapour pressure of water at 363 K and 373 K are respectively 70.11 kPa and 101.325 kPa. Estimate the mean heat of vaporization of water in this temperature range? 07
- Q.5 (a) Dry methane and dry air at 298 K and 1 bar pressure are burnt with 100 % excess air. The standard heat of reaction is -802 kJ/gmol of methane. Determine the final temperature attained by gaseous products if combustion is adiabatic and 20 % of heat produced is lost to the surroundings. Data: C_{pm} values (J/ (gmol K)) for the components are: O₂ : 31.9, N₂ : 32.15, H₂O : 40.19, CO₂: 51.79. 07
- (b) define the following terms 07
- (1) Dry-bulb temperature
 - (2) Wet bulb temperature
 - (3) Latent heat
 - (4) Absolute humidity
 - (5) Percentage humidity
 - (6) Dew point
 - (7) Humid heat

OR

Q.5 (a) Calculate the heat of reaction at 700 K using the following.

07



$$C_p^0 = a + bT + cT^2 \text{ kJ/(kmol K)}$$

Comp.	$\Delta H_{f,298}^0$ (kJ/mol)	a	b x 10 ³	c x 10 ⁶
SO ₂	-296.81	24.77	62.95	-44.26
O ₂	0.0	26.026	11.755	-2.3426
SO ₃	-395.72	22.04	121.6	-91.87

(b) Differentiate between: (i) Sensible heat and latent heat (ii) Endothermic and exothermic reactions. 07
