B.E FOOD TECHNOLOGY AND BIOCHEMICAL ENGINEERING FIRST YEAR SECOND SEMESTER EXAM 2019 (Old)

CHEMICAL ENGINEERING FUNDAMENTALS.

Time : 3 Hours **Full Marks: 100**

Use a separate answerscript for each part.

PART I (Marks)

Answer Question no. 5 and any two from the rest

1. (a) What is the difference between volumetric flow rate and mass flow rate? The flow rate of water through a pipe is 15 ft^3 /min. Taking density of water as 1g/cm^3, calculate the mass flow rate in kg/hr. 10

(b) A cellulose solution contains 9% cellulose by weight in water. What amount of 2.5% cellulose solution is required to dilute 100 kg of 9% cellulose to 6%? 10

2.. The combustible matter in a certain sample of coal is found to be 82% C and 18% H by weight. If 50 kg of such coal is burnt with 100 kg of air, the Orsat analysis of the combustion gas showed CO_2: CO in the ratio 3:2. Determine (a) the percent excess air (b) the composition of the flue gas 20

3. The following data were obtained in a test on coal-fired steam generator. The ultimate analysis of coal is: C-80.5%, H- 4.6%, O-0. 5% , N-11%, ash-3.4%. No carbon is lost in the refuse. Orsat analysis of the flue gas is: CO_2-16.4%, O_2-2.3%, CO-0.4%, N_2- 80.9%. Calculate:

(a) the weight of the dry gaseous products formed per 100 kg of coal fired.

(b) the percent excess air supplied for combustion. 20

4. In a process producing KNO_3 salt, 900 kg of a feed solution containing 13% KNO_3 is fed to an evaporator which evaporates water to produce a 50% KNO_3 solution. This is then fed to a crystallizer, where crystals containing 95% KNO_3 are removed. The saturated solution containing 35% KNO_3 from the crystallizer is recycled to the evaporator. Calculate the following:

(a) amount of the recycle stream , kg/hr

(b) amount of crystals withdrawn from the crystallizer, kg/hr

(c) the quantity of water evaporated from the evaporator, kg/hr 20

5 (a). Find out the value of the Reynolds Number ($D v \rho / \mu$) from the following data:

D= 4 mm, v= 3cm/s, ρ =24 lb/ft 3 and $\mu = 1 \times 10^6$ cp. 5

(b) What is the importance of recycle in food process industries? 5

Ex/FTBE/T/123/2019(Old)

B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING

FIRST YEAR SECOND SEMESTER EXAM (OLD) 2019

Chemical Engineering Fundamentals

Time: 3 hrs. Full Marks : 100

Part – II (50 Marks)

Answer any four of the flowing questions

1. (i) Define the following with proper example : state function, closed system
   (ii) What is 'standard state' of an element ?
   (iii) What are extensive properties of a system? Give example.
   (iv) What do you mean by 'Van't Hoff Box' ?
   (v) State the first law of thermodynamics.
   (vi) Show how standard heat of a reaction is related to standard heat of formation of products and reactants. (2+2+2+2+2+2.5)

2. (i) When a system is taken from state a to state b along a particular path acb, 80J of heat flows into the system and the system does 30J of work. How much heat flows into the system along another path aeb if the work done by the system is 20J? The system returns from b to a along a path bda. If the work done on the system is 40J, does the system absorb or liberate heat? How much?
   (ii) The sulphate process for the production of HCl is described by the equation :

   $$NaCl+H_2SO_4 \longrightarrow Na_2SO_4 + HCl.$$

   Calculate the heat of reaction and also state whether the reaction is endothermic or exothermic. The heat of formation in MJ/Kmol for NaCl , H_2SO_4 , Na_2SO_4 and HCl are -410, -815, -1390 and -95, respectively. (6.5+6)

3. (i) Calculate heat of reaction of the following reaction at 500K and 1atm pressure:

   $H_2 + Cl_2 \longrightarrow HCl$

   Data given: $\overline{Cp}$ of H_2 = 29.46 kJ /kmol-K ; $\overline{Cp}$ of Cl_2 = 37kJ/kmol-K; $\overline{Cp}$ of HCl = 30 kJ/kmol-K (considering 500K) and $\Delta H^0_{f(HCl)}$ = -90,000kJ/kmol
   (ii) Water enters a boiler at 136kPa and 35^{0}C, through a 100mm pipe at an average velocity of 1.75 m/s and steam leaves at 315^{0}C and a pressure of 2860kPa. At what rate water must be supplied to the boiler under steady state conditions?

   Data given: at 136kPa and 35^{0}C specific enthalpy of water =146.5kJ/kg and at 2860kPa & 315^{0}C, specific enthalpy of steam = 3040kJ/kg (6 + 6.5)

[Turn over

4. 10 m^3 of dry CO_2 at 200kPa and 50°C is to be fed into a chamber to cool it at 20^0C.The gas is inside a copper tube with an internal diameter of 25mm and wall thickness of 1.30mm surrounded by another copper tube with an internal diameter of 35 mm and wall thickness of 1.70mm. Water flows through the annular space at a velocity of 0.15 m/sec. Water enters at 15°C and flows counter current to the gas. Calculate the outlet temperature of water. Assume that specific heat for water is 4.19 kJ/kg-K and heat capacity (Cp) of CO_2 at a average temperature of 35^0C is 0.80 kJ / kg-K. 12.5

5. A 500 gallon continuous stirred tank reactor is being fed with 1,000 lb_m /hr of feed at 70^0F with a concentration of 0.5 lb-mole of reactant A per ft^3 . Some of the reactant A is consumed in the reactor , producing product B. The concentration of the reactant in the stream leaving the reactor is 0.25 lb-mole of A per $ft^3$and the temperature of this stream is 140^0F. The heat capacity of the reactant and the product are both 0.75 Btu/lb_m-^{0}F and their densities are both 50 lb_m/ft^3. The reaction is exothermic, giving of 25,000 Btu/lb-mole of A reacted. How much heat must be removed from the reactor ? if cooling water at 70^0F is fed into the cooling jacket surrounding the reactor and leaves the jacket at 118^0F, how much cooling water must be used? Assume 1 gallon of water to be 8.33 lb_m of water. 12.5

6. Lemon juice is being concentrated with the help of an evaporator from 10 weight percent solids to 30 weight percent solids with no boiling point rise. Liquid enthalpies may be assumed to be those of pure water. The evaporator operates at 40^0C, with feed entering at 30^0C. Saturated steam is used at 60^0C. The overall heat transfer coefficient is 350BTU/hr. $ft^2.^0$F. Calculate the heat transfer area and the steam requirement flow rate to produce 2,000lb/hr of lemon juice concentrate. Steam table data: enthalpy of water at 30^0C , 40^0C and 60^0C are 54BTU/lb , 72BTU/lb & 108BTU/lb ,respectively ; enthalpy of water vapour at 40^0C and 60^0C are 1106BTU/lb & 1122BTU/lb, respectively. 12.5

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