Ref. No. : Ex/FTBE/T/123/2018

Name of the Examinations: B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING FIRST YEAR SECOND SEMESTER - 2018

Subject : CHEMICAL ENGINEERING FUNDAMENTALS   Time : 3 Hours   Full Marks : 100

Part I (50 Marks)

Instructions : Use Separate Answer scripts for each Part.

GROUP I

Answer Question Number 1 or 2.

1. (a) State the difference between units and dimensions? 3

(b) Identify whether the equation for flow through a rectangular weir is dimensionally consistent:

$Q = 0.415\,(L-0.2h_0)\,(h_0)^{1.5}\,(2g)^{0.5}$

Where, Q= volumetric flow rate, ft^3/s,

L= Crest height, ft,

h_0 = weir head, ft,

g= acceleration due to gravity, ft/s^2.   7

2. Convert $\dfrac{7.8\,(\text{inch}).(\text{cm}^2)}{(\text{yr})\,)(\text{s})\,(\text{lb}_m)\,(\text{ft}^2)}$ to all SI units.   10

GROUP II

Answer question number 3 or 4.

3. (a) in the processing of fish, after the oil is extracted, the fish cake is dried in a rotary drum dryer, finely ground and packed. In a given batch of fish cake that contains 85% water (the remainder being dry cake), 95 kg of water is removed and it is found that the fish cake is then 40% water. Calculate the weight the fish cake that was originally put into the dryer.   10

(b) In a food industry, a single effect evaporator concentrates a 4% (by mass) food solution to 25% solids (by mass). Calculate how much water is evaporated per 100 kg of feed to the evaporator. How many independent material balance equations can be written for this problem?   8+2

4. (a) What is recycling and how is it important for the chemical process industry?   5

(b) Dry salt is to be produced at the rate of 18,000 kg/hr by evaporating water from a feed containing 20% NaCl. The brine (27% NaCl) leaving the evaporator may either be recycled to the evaporator or may be discarded. If the brine produced is 25% of the weight of dry salt, calculate the following:

(i) the feed rate if the brine is recycled.

(ii) the percent excess of the feed rate if the brine is discarded over that required when the brine is recycled. 15.

Group III

Answer question number 5 **or** 6

5. (a) How is the percent excess air calculated for problems on material balance with chemical reactions? 3.

(b) Hydrogen free coke containing 85% carbon (by weight) and the rest inert materials is burnt in a furnace. It is found that during combustion 5% of the coke charged is lost unburnt. The flue gas analysis shows 14.84% CO_2, 1.65% CO, 5.16% O_2 and 78.35% N_2. Calculate the following:

(i) The percent excess air on the basis of complete combustion of coke.

(ii) kg moles of air supplied per 100 kg of coke charged to the furnace.

(iii) kg mole of flue gas formed per 100 kg of coke charged. 17.

6. Wet solid containing 70% water is mixed with recycled dry solid to reduce the water content to 50% before being admitted to the granulator. The solid leaving the granulator is fed to a dryer where it is brought into contact with dry air initially containing 0.25% water by weight. In the dryer, the air picked up moisture and leaves with a moisture content of 5%. The solids leaving the dryer contains 20% water. A portion of this solid is recycled.

For 1000 kg/ hr of wet solid sent to the granulator as fresh feed determine the following:

(i) The amount of solid recycled.

(ii) The circulation rate of air in the dryer on dry basis. 20.

B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING

FIRST YEAR SECOND SEMESTER EXAM 2018

Chemical Engineering Fundamentals

Time: 3 hrs. Full Marks : 100

Part – II (50 Marks)

1. Answer any two from the following (a) , (b) and (c)

(a) (i) Define the following with proper example : closed system, path function

(ii) What is 'standard heat of formation' of a compound?

(iii) What is 'standard state' of an element ?

(iv) What do you mean by 'Van't Hoff Box' ?

(v) Give example of a state function which is derived out of where two path functions

(vi) What is the basis of steam table ?

(vii) What do you mean by BPR and Duhring chart? 2+1+1+2+1+1+2

(b) (i) Determine the heat of reaction for the following at STP and state whether the reaction is endothermic or exothermic : $Na_2CO_3 + Ca(OH)_2 \longrightarrow CaCO_3 + NaOH$. Data given : ΔH_f^0 values for Na_2CO_3, $Ca(OH)_2$, $CaCO_3$ and NaOH are -288.5 , -102 , -270.3 and -235.8 kcal/g mol respectively.

(ii) When a system is taken from state a to state b along a particular path acb, 100J of heat flows into the system and the system dos 40J 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 30J, does the system absorb or liberate heat? How much? 5+5

(c) (i) Water flows over a water fall 100m in height. Consider 1kg of the water and assume that no energy is exchanged between the 1 kg and its surroundings. (a) What is the potential energy of the water at the top of the falls with respect to the base of the falls? (b) What is the kinetic energy of the water just before it strikes bottom (c) After 1kg of water enters the river below the falls, what change has occurred in its state? Assume that 4184 J kg^{-1} is required for a temperature rise of 1^0C in water.

(ii) Calculate heat of reaction of the following reaction at 1000K 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 and $\Delta H^0_{f(HCl)}$ = -90,000kJ/kmol 5+5

2. Answer any two from the following (a) , (b) ,(c), (d) and (e)

(a) 15 m^3 of dry CO_2 at 200kPa and 40°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 1.20mm surrounded by another copper tube with an internal diameter of 35 mm and wall thickness of 1.65mm. 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 30^0C is 0.80 kJ / kg-K. 15

(b) Ammonium sulphate is to be crystallized from a solution containing 48% ammonium sulphate by cooling it in a counter current crystallizer from 85 to 35^0C.During cooling the amount of water that evaporates is 5% of the feed. If the feed rate is 1500 kg/hr, calculate
(i) the rate of formation of crystal (ii) the rate of supply of cooling water if heated from 18 to 30^0C (iii) required cooling surface required .
Data given: Overall heat transfer coefficient of the cooling surface is 115w/m^2-K;
Solubility of ammonium sulphate at 35^0C is 75kg /100 kg of water; Specific heat of 48% ammonium sulphate is 2.97kJ/kg; Heat of crystallization of ammonium sulphate is 75.2kJ/kg;
Latent heat of evaporation of water at 35^0C is 2414kJ/kg 15

(c) A 500 gallon continuous stirred tank reactor (CSTR) is fed 2,780 lb_m /hr of feed at 70^0Fwith 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 0.245 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 30,000 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. 15

(d) An evaporator is used to concentrate orange juice from 12 weight percent solids to 48 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 3,000lb/hr of orange 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. 15

(e) A saline solution is evaporated in a short-tube vertical evaporator. The feed concentration is 10 weight percent solids and the feed temperature is 80^0F . The concentrated liquid product from the evaporator is 35 weight percent solids. The pressure inside the evaporator is 5psia.Saturated stem at 30psig is used as the energy source. The saline solution has a heat capacity that is 0.95BTU/lb.^{0}F at 10 weight percent and 0.85 BTU/lb.^{0}F at 35 weight percent. The overall heat transfer coefficient is 400 BTU/hr.ft^2.^{0}F. Determine the heat transfer area required to produce2500lb/hr of concentrated product assuming BPR.
Boiling point of pure water at 5psia is 162^0F. From Duhring chart BPR for this case is found to be 32^0F . enthalpy of water vapour at 194^0F is 1146BTU/lb. The temperature of saturated condensing steam at 30psig is 274^0F. 15