Ref. No. : Ex/FTBE/BS/B/T/214/2023(S)

Name of the Examinations: B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER SUPPLEMENTARY EXAM - 2023

Subject : CHEMICAL ENGINEERING FUNDAMENTALS **Time : 3 hours** **Full Marks : 100**

Use separate answer script for each Part

Part I (50 Marks)

Answer Question no. 5 and any two from the rest.

1. (a) The equation for the velocity of a fluid stream measured with a Pitot Tube is
$v = \sqrt{(2 \Delta p/\rho)}$
Where v= velocity, Δp= pressure drop, ρ= density of fluid
Is this equation dimensionally consistent? If the pressure drop is 40 mm Hg and the density of the fluid is 1.560 g/ cm^3, calculate the velocity in ft/s. 10

(b) Water is flowing through a 2.5 inch diameter pipe with a velocity of 3 ft/s. What is the flow rate in (I) gal/min (ii) kg/min.
(Flow rate= cross sectional area of the pipe × velocity). 10.

2. (a) An aqueous solution containing 14% acetic acid is added to another aqueous solution containing 33% acetic acid flowing at the rate of 27 kg/min. The product of the combination leaves at the rate of 100 kg/min. What is the composition of the product stream? 10

(b) A cereal product containing 60% water is fed to an evaporator at the rate of 540 kg/hr. How much water is to be evaporated if the final product is to contain 25% water? 10.

3. The Orsat analysis of the flue gas produced by the combustion of pure methane in excess of dry air is 8.15% CO_2, 0.98% CO, 5.04% O_2 and 85.83% N_2. Calculate the percent excess air used for combustion. 20

4. In the production of potassium nitrate crystals, 10,000 kg/hr of a 25% KNO_3 solution is mixed with a recycle stream and sent to an evaporator. The rate of evaporation is 1.25 times the rate of introduction of recycle stream. The concentrated solution leaving the evaporator contains 55% KNO_3. This stream is admitted to the crystallizer which yields crystals containing 5% water. At the crystallisation temperature, the solubility of KNO_3 is 60 kg/100 kg of water. Major part of the mother liquor leaving the crystallizer is returned to the evaporator as recycle stream. Calculate:
   (i) The concentration of KNO_3 in the combined stream entering the evaporator.
   (ii) The amount of recycle stream per hour.
   (iii) The rate of production of crystals in kg/hr.

5. Answer any one. (10).
   (a) What is the difference between units and dimensions? Explain with examples. What is flue gas? How is excess air or oxygen fed to a burner calculated? 5+2+3
   (b) 50 pounds of water is flowing through a pipe at the rate of 10 ft/s. Calculate the kinetic energy of water in the SI system. 10

[Turn over

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B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER SUPPLEMENTARY EXAM – 2023

Department: Food Technology and Bio-Chemical Engineering (F.T.B.E)

Subject: Chemical Engineering Fundamentals (FTBE/BS/B/T/214)

Year: 2nd Semester: 1st

Part II

(50 Marks)

Answer Q.1 (compulsory) and any two from the following:

Q.1. (i) A gas containing 40% CO and 60% N_2 by volume is burnt completely with 10% excess air. If 282.1 MJ of heat is evolved per k.mol of CO burnt, what would be the temperature of the combustion products? Assume that the gas and air are at 30°C. Average heat capacities in kJ/k.mol °K are as follows: CO 33.08, CO_2 50.66, O_2 33.08, N_2 31.4

(ii) Estimate the inlet and outlet compositions (in mole percent). What is mole ratio of the combustible gas and the air at the inlet of the combustion chamber? **12+8 =20**

Q.2. (i) The heat of formation of H_2O (g)is -58 k.cal at 500°K. What will be the heat of formation at 800°K? The molar heat capacities in cal/mol °K are given as follows:
$C_p(H_2) = 7 - 0.2\times10^{-3}T$, $C_p(O_2) = 6.0+4\times10^{-3}T$, $C_p(H_2O) = 7.25 + 0.2\times10^{-3}T$
(ii) Given the heats of formation of NH_3 and HF gas are -46.1 kJ and -271.1 kJ, respectively. Find out the heat of gaseous reaction, $2NH_3 + 3F_2 = N_2 + 6HF$ **8 +7 =15**

Q.3. (i) Calculate the heat of reaction of water gas at 1500°C, $C(s)+H_2O(g) = CO(g)+H_2(g)$, At 25°C, ΔH_f, $H_2O(g)$ = -242.0 MJ/k.mol and ΔH_f, CO(g) = -110.6 MJ/k.mol, Mean heat capacities in kJ/k.mol °K: C(s) = 9.67, $H_2O(g)$ = 41.41, CO (g) = 32.95, $H_2(g)$ = 30.88
(ii) Calculate the heat produced in the reaction, $3Mg + Fe_2O_3 = 3MgO + 2Fe$, Given: ΔH_f, MgO= -145.7 K.cal/ mol andΔH_f, Fe_2O_3= -193.5 K.cal/mol **10+5 = 15**

Q.4. (i) 200 moles of CH_4 is burnt in presence of theoretical amount of air. Estimate the fuel- air ratio for such combustion process. Also estimate the mole ratio of the inlet and outlet stream.
(ii) If the same amount of the fuel is to be burnt in presence of 20% excess air, then what percentage of the air-fuel ratio is changed? **12+3 =15**

Q.5. Write short notes on (with examples) the following: **5×3 =15**
(i) Heat of Formation (ii) Adiabatic Flame temperature (iii) Laws of Thermochemistry
(iv) Heat of reaction (v) Heat capacity