Ref. No. : Ex/FTBE/BS/B/T/214/2025

Name of the Examinations: B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER - 2025

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

Part 1 (50 Marks)

Instructions : Use Separate Answer scripts for each Part
Answer Question no. 6 and any three from the rest.

1. (a) What is a fundamental unit and a derived unit? Give examples of one each.
   (b) The flow rate of water through a pipe is 16 ft^3/min. Taking density of water as 1g/cm^3, calculate the mass flow rate in kg/s.
   (c) The weight of an object is 320 N at a location where acceleration due to gravity is 9.82 m/s^2
   (i) Determine the mass of the object in kilograms.
   (ii) Express the mass of the object in FPS system.

   2+8+8

2. A food product containing 65% water is fed into an evaporator at the rate of 510 kg/hr. How much water has to be evaporated per hour so that the final product contains 30% water?

   10

3. An aqueous solution of ethanol containing 10% by weight ethanol is continuously distilled at a rate of 1020 kg/hr in a distillation column. Ten percent of the feed is recovered as distillate product (overhead) which contains 60% ethanol and 40% water. Calculate the composition of the bottom product.

   10

4. When coal containing 75% C, 14.8% H, and 10.2% ash is burned in air, it gives a flue gas containing 12.4% CO_2, 1.1% CO, 1.5% O_2 and 85% N_2 on a dry basis. Determine the following
   (a) The mass of coal fired in kgs per kg mole of dry flue gas.
   (b) The percent excess air used.

   10

5. The combustible matter in a certain sample of coal is found to be 80% C and 20% H by weight. 50 kg of coal is burnt with 1000 kg of air. The Orsat analysis (dry basis) of the combustion gas showed CO_2 to CO in the ratio 3:2

   Determine the percent excess air. 10

6. (a) State any two advantages of recycling a steam in a process.
   (b) Dry salt is to be produced at a rate of 26000 kg/hr by evaporating water from a feed containing 25% NaCl. The brine (28% NaCl) leaving the evaporator may either be recycled to the evaporator or may be discarded. If the brine produced is 30% of the weight of dry salt, calculate the following:

7. (a) The feed rate if the brine is recycled
   (b) The percent excess of the feed rate if the brine is discarded over that when the brine is recycled.

   4+16

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B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAM - 2025

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

Marks: 50

Answer Q.3 (compulsory) and any two from the following:

Q.1. The exhaust gases from a pyrites roasting furnace leaves at 600°C and has the following composition by volume: SO_2 = 7.05%, O_2 = 10.5%, SO_3 = 0.79% and N_2 = 81.66%. If 1 kmol of the gas mixture is cooled to 77°C, calculate the total quantity of heat released. The specific heats of individual components expressed in kJ/kmol °K are

$C_p\,(SO_2) = 25.74 + 5.8\times10^{-2}T$, $C_p\,(O_2) = 28.19 + 0.63\times10^{-2}T$, $C_p\,(SO_3) = 25.44 + 9.85\times10^{-2}T$

$C_p\,(N_2) = 27.34 + 0.62\times10^{-2}T$ **15**

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 1000°K? The molar heat capacities in cal/mol °K are given as follows:

$C_p\,(H_2) = 7 - 0.2\times10^{-3}T$, $C_p\,(O_2) = 6.2 + 3.2\times10^{-3}T$, $C_p\,(H_2O) = 7.25 + 0.2\times10^{-3}T$

(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 1100°K, $C(s) + H_2O(g) = CO(g) + H_2(g)$. At 27°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) A gas containing 20% CO and 80% N_2 by volume is burnt completely with 100% 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 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? **6+12+2 = 20**

Q.4. CH_4 at 50°C and air at 200°C are mixed together to yield a mixture containing CH_4 and O_2, and N_2. The volumetric composition shows equal amounts of CH_4 and O_2, and the rest N_2. This gas mixture is to be heated to 500 °C. Calculate the final temperature after mixing and the amount of heat required to heat this mixture containing 80 kg of O_2. Assume that, $C_{p,\,methane} = 14.15 + 0.0755T$, kJ/kmol °K and $C_{p,\,air} = 27.37 + 0.0062T$, kJ/kmol °K **6+9 =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