Ex/FTBE/BS/B/T/214/2023

B. E. Food Technology and Bio-Chemical Engineering Examination, 2023

(2nd Year, 1st Semester)

Chemical Engineering Fundamentals

Time : 3 hoors Full Marks : 100

(50 Marks for each Part)

Use separate answer script for each Part

PART I (50 Marks)

Answer question no. 1 and any two from the rest.

1. (a) The mass velocity of a gas through a duct is 1000 kg/m^2.hr. Express the velocity in lb/ft^2.s. 10

OR

(b) A man circling the earth in a spaceship weighed 300 N at a location where the local gravitational acceleration was 4.5 m^2/s. Calculate the mass of the man and his weight on the earth where the gravitational acceleration is 9.81m /s^2. 10

2. (a) A food substance containing 40% moisture is dried to 5% moisture. What is the mass of water evaporated in kg per 100 kg of the feed? 10

(b) A water solution containing 12% acetic acid is added to a water solution containing 35% acetic acid flowing at the rate of 22 kg/min. The product P of the combination leaves at the rate 100 kg/min. What is the composition of P? 10

3. The Orsat analysis of the flue gas produced by the combustion of pure methane in excess of dry air is 8.17% CO_2, 0.96% 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 20% 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 50% KNO_3. This stream is admitted to the crystallizer which yields crystals containing 4% 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. 20

5. 120 kg mol of a hydrocarbon mixture containing 25% ethane, 35% propane and 40% butane is sent to the first column of a series of two distillation columns. The top product from the first column contains 95% ethane, 3% propane and 2% butane. The bottom stream enters the second column in the series where it is subjected to further purification. The distillate leaving the second column is 99% propane and 1% butane and the bottom product is 7.4% propane and 92.6% butane. Calculate:
   (i) The quantity and composition of the bottom product from the first column and
   (ii) The quantity of the distillate from the second column. 20

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B. E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING EXAMINATION, 2023

(2nd Year, 1st Semester)

CHEMICAL ENGINEERING FUNDAMENTALS

Time : 3 hoors Full Marks : 100

(50 Marks for each Part)

Use separate answer script for each Part

PART II (50 Marks)

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

Q.1. (i) 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

(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 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 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 andΔH_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 25% excess 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 theoretical amount of 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