Ref. No. : Ex/FTBE/BS/B/T/214/2024

B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER - 2024

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

Use separate answerscript for each part.

Part A

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 35 mm Hg and the density of the fluid is 1.40 g/cm^3, calculate the velocity in ft/s. 10

   (b) Water is flowing a 2 inch diameter pipe with a velocity of 5 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) A lacquer plant must deliver 850 kg of a 7.5% nitrocellulose solution. They have in stock 6.3% nitrocellulose solution. How much dry nitrocellulose must be dissolved in the solution to deliver the order? 10

   (b) A food product containing 65% water is fed to a dryer at the rate of 550 kg/hr. How much water is to be evaporated per hour so that the product contains 40% water? 10.

3. Hydrogen free coke containing 86% carbon (by mass) 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, 1.64% CO, 5.17% O_2 and 78.35% N_2. Calculate the following:

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

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

   (iii) Amount of flue gas generated in kg moles per 100 kg of coke charged. 20

4. A feed steam containing 26% vitamins is fed to a centrifuge at the rate of 100 kg/hr. After separation of water, the stream coming out of the centrifuge contains 40% vitamins. This stream is fed to a continuous filter from where the output stream contains 96% vitamins. A recycle stream from the filter containing 29% vitamins is mixed with the feed stream at the entry point to the centrifuge. Calculate the amount of the recycled stream in kg/hr. 20

5. Answer any one (10)

   (a) What is a recycle stream and what is its importance in the process industry?

   (b) What is the difference between units and dimensions? Explain with examples. How is percent excess air supplied to a burner during a combustion process is calculated? 5+5

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B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAM – 2024

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

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

Year: 2nd Semester: 1st

Full Marks: 50

Part II

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

Q.1. (i) A gas containing 50% CO and 50% N_2 by volume is burnt completely with 1.75 times the theoritical air. If 280 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 27°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 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 727°C? 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. (a) Calculate the heat produced for the formation of C_6H_6 from the polymerization of C_2H_2 at constant pressure from the following data: At constant volume, 27°C
(i) $2\ C_6H_6 + 15O_2 = 12\ CO_2 + 6\ H_2O$, ΔH= - 1600 Kcal
(ii) $2\ C_2H_2 + 5O_2 = 4\ CO_2 + 2\ H_2O$, ΔH= - 620 Kcal
(b) 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) 320 kg of CH_4 is burnt in presence of theoretical amount of air. Estimate the fuel- air ratio for such combustion process. Also estimate the product distribution (mole%) at the exit. (ii) Estimate the mean heat capacity of CH_4 if it is heated from 27°C to 227°C, assuming the heat capacity of CH_4 is as follows: $C_p(CH_4) = 14.15 + 0.0755T$ kJ/ k-mol-°K **10+5 =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