17315

11920

3 Hours / 100 Marks Seat No. | | | | | | | | |

Instructions : (1) All Questions are *compulsory.*

(2) Answer each next main Question on a new page.

(3) Illustrate your answers with neat sketches wherever necessary.

(4) Figures to the right indicate full marks.

(5) Assume suitable data, if necessary.

(6) Use of Non-programmable Electronic Pocket Calculator is permissible.

(7) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

Marks

1. (A) Answer any FOUR : **8**

(a) Give the expression for ideal gas law. Explain the terms involved.

(b) Define limiting component and excess component.

(c) Give the value of R in S.I.

(d) Define Amagat's law with mathematical expression.

(e) Define :

(i) Adiabatic reaction

(ii) Adiabatic reaction temperature

(f) Define :

(i) % conversion

(ii) % yield

(B) Answer any TWO : **12**

(a) A natural gas has the following composition by volume : CH_4 = 82%, C_2H_6 = 12%, N_2 = 6%. Calculate :

(i) density of gas at 288 K & 101.325 KPa

(ii) Composition in weight %

(b) A gas contained in a closed vessel at a pressure of 121.59 KPa g and 299 K (26°C) is heated to a temperature of 127. K (1000°C). Find the pressure to which a closed vessel should be designed.

(c) The Henry's law constant for CO_2 in water at 313 K is 7.05×10^6 KPa/mol fractions. Find partial pressure of CO_2 in the gas phase if mol fraction of CO_2 dissolved in liquid is 4.2×10^{-6}.

2. Attempt any FOUR : **16**

(a) A single effect evaporator concentrating a weak liquor containing 4% solids to 55% solids (by weight) is fed with 5000 kg/hr of weak liquor. Calculate :

(i) water evaporated per hour

(ii) flow rate of thick liquor

(b) 2000 kg of wet solids containing 70% solids by weight are fed to tray dryer where it is dried by hot air. The product finally obtained is found to contain 1% moisture by weight. Calculate :

(i) kg of water removed from wet solids.

(ii) kg of product obtained.

(c) Ammonia is produced by following reaction :

$$N_2 + 3H_2 \rightarrow 2NH_3$$

Calculate :

(i) The molal flow rate of hydrogen corresponding to nitrogen feed rate of 25 k mol/hr, if they are fed in the stoichiometric proportion.

(ii) The kg of ammonia produced per hour if % conv. is 25 and nitrogen feed rate is 25 k mol/hr.

(d) In production of SO_3, 200 k/moles of SO_2 and 400 k/moles of O_2 are fed to reactor. The product stream is found to contain 150 k/moles SO_3. Find % conversion of SO_2.

(e) A combustion reactor is fed with 50 k/moles of butane and 2100 k/moles of air/hr. Calculate the % excess air used.

(f) At what rate in kcal/hr heat must be transferred to liquid C_2H_5OH at its boiling point to generate 100 kg/hr of C_2H_5OH vapour ? $\lambda = 202$ kcal/kg.

3. Attempt any TWO : **16**

(a) Ethylene oxide is produced by the oxidation of ethylene. 100 k/moles of ethylene fed to a reactor and product is found to contain 75 k/moles C_2H_4O and 10 k/moles CO_2. Calculate :

(i) % conversion of ethylene

(ii) % yield of C_2H_4O

(b) The feed containing 50% benzene and 50% toluene is fed to a distillation column at a rate of 5000 kg/hr. A top product contains 95% benzene and bottom product contains 92% toluene (by weight). Calculate :

(i) the mass flow rate of top and bottom products

(ii) % recovery of benzene

(c) Centrifuge is fed with a slurry containing 25% solids. Wet solids obtained after filtration are analysed to contain 8% moisture by weight and filtrate is found to contain 200 ppm solids. If machine produces 100 kg/hr desired wet product and quantity of slurry to be handled is 5000 kg/batch, calculate :

(i) time required for filtration of slurry

(ii) loss of solids in filtrate per batch

4. Attempt any TWO : **16**

(a) Calculate the heat of formation of liquid 1-3 butadiene (C_4H_6) at 298.15 K using following data :

Std. heat of formation of $CO_{2(g)} = -393.51$ kJ/mol

Std. heat of formation of $H_2O_{(l)} = -285.83$ kJ/mol

Heat of combustion of $C_4H_{6(l)} = -2520.11$ kJ/mol

(b) The waste acid from a nitrating process containing 20% HNO_3, 55% H_2SO_4 and 25% H_2O by weight is to be concentrated by addition of con. H_2SO_4 containing 95% H_2SO_4 and conc. HNO_3 containing 90% HNO_3 to get desired mixed acid containing 26% HNO_3, 60% H_2SO_4. Calculate the quantities of waste and concentrated acids required for 1000 kg of desired mixed acid.

(c) SO_2 is oxidised to SO_3. If % conversion is 70 and air is used 80% in excess over theoretical requirement, calculate :

(i) k/moles of air fed per k/mole SO_2

(ii) Compostion of gas leaving reactor on volume basis

5. Attempt any TWO : **16**

(a) The feed containing 60 mol % A, 30 mol % B and 10 mol % inserts enters a reactor. The product stream leaving the reactor is found to contain 2 mol % A. The reaction taking place is $2A + B \rightarrow C$. Find % of original A getting converted to C.

(b) A feed stream to a process is to consist of 500 kg/hr of a gas containing 30 mol % N_2 and 70 mol % H_2. The stream is obtained by blending gases from two tanks, both tanks contain $H_2 - N_2$ mixture. Tank 1 contains 10% N_2 and tank 2 contains 50% N_2 (% are by volume). Calculate the required flow rates of gas mixture from tank 1 and tank 2.

(c) Calculate the enthalpy change between reactants and products if both are at 298.15 K and if 60 mol of CO_2 is produced according to the reaction

$2C_4H_{10(g)} + 13\ O_{2(g)} \rightarrow 8\ CO_{2(g)} + 10\ H_2O_{(l)}$

Component	$\Delta H°f$ kJ/mol at 298.15 K
$C_4H_{10(g)}$	–125.79
$CO_{2(g)}$	–393.51
$H_2O_{(l)}$	–285.83

6. Attempt any FOUR : **16**

(a) In manufacture of SO_3 feed to reactor consists of 50 k/mol SO_2 and 150 k/mol air. Calculate % excess air used over theoretical requirement.

(b) The NH_3-air mixture containing 0.2 kg NH_3 per kg air enters into absorption system where NH_3 is absorbed in water. The gas leaving the system is found to contain 0.004 kg NH_3 per kg air. Find % recovery of ammonia.

(c) A sample of coal is found to contain 63% C and 24% ash on weight basis. The analysis of refuse after combustion shows 7% C and rest ash. Calculate % of original C unburnt in the refuse.

(d) For the manufacture of Cl_2, a dry mixture of HCl gas and air is passed over a heated catalyst which promotes oxidation of acid. Air is used 30% excess of that theoretically required. Calculate the weight of air supplied per kg acid.

(e) Formaldehyde is produced from CH_3OH in catalytic reactor. The production rate of HCHO is 1000 kg/hr. If the conversion of methanol is 65%, calculate the required feed rate of methanol.

(f) Calculate the heat that must be transferred to 3 k/mol air to heat it from 25°C to 200°C using mean molal heat capacity data for oxygen. CP_m^o (between 200°C and 25°C) for air = 29.3955 kJ/(k/mol·k)
