22232

3 Hours / 70 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) Assume suitable data, if necessary.

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

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

Marks

1. Attempt any FIVE of the following : **10**

(a) Write material balance equation of extraction.

(b) State Hess's law of constant heat summation.

(c) Define work and write its SI unit.

(d) Convert a pressure of 2 ATM to the following units :

(i) mmHg

(ii) kPa

(e) Define limiting reactant and excess reactant.

(f) State Amagat's law and Dalton's law.

(g) Define NCV and GCV.

2. Attempt any THREE of the following : **12**

(a) A mixture of phenol and water forms two separate liquid phases, one rich in phenol and other rich in water, composition of layers is 70% and 9% (by weight) phenol respectively. If 500 kg of phenol and 700 kg of water are mixed and layers allowed to separate, what will be the weights of two layers ?

(b) A natural gas has the following composition by volume :

CH_4 = 82%, C_2H_6 = 12% and N_2 = 6%

Calculate the density of gas at 288 ºk and 101.325 kPa.

(c) Calculate the standard heat of reaction of the following reaction :

$4\ NH_3(g) + 5O_2(g) \longrightarrow 4\ NO(g) + 6H_2O(g)$

Data :

Component	**ΔH^o_f, kJ/mol at 298.15 ºk**
$NH_3(g)$	–45.94
NO(g)	90.25
$H_2O(g)$	–241.82

(d) In production of sulphur trioxide, 100 kmol of SO_2 and 100 kmol of O_2 are fed to a reactor. If the percent conversion of SO_2 is 80, calculate the composition of the product stream on mole basis.

3. Attempt any THREE of the following : **12**

(a) A feed containing 60 mole % 'A', 30 mole % 'B' and 10 mole % 'C' inerts enters a reactor. 80 percent of original 'A' reacts according to the following reaction :

$$2A + B \rightarrow C$$

Find the composition of the product stream on mole basis.

(b) A mixture of CH_4 and C_2H_6 has the average molecular weight of 22.4. Find mole % CH_4 and C_2H_6 in the mixture.

(c) Convert a volumetric flowrate of 7200 M^3/hr to Lit/sec.

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

(i) The kg of water removed from wet solids

(ii) The kg of product obtained.

4. Attempt any THREE of the following : **12**

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

(b) A certain sample of gas at a pressure of 202.65 kPa pressure is expanded so that its volume is increased by 50%. The operation is done for a fixed mass of gas at constant temperature. Calculate final pressure of gas.

(c) The ground-nut seeds containing 45% oil and 45% solids are fed to expeller, the cake coming out of expeller is found to contain 80% solids and 5% oil. Find the percentage recovery of oil.

(d) Methane gas is heated from 303 ºk to 523 ºk at atmospheric pressure. Calculate the heat added per kmol methane using C_p^o data given below :

Data : $C_p^o = a + bT + cT^2 + dT^3$ kJ/(kmol.ºk)

Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
Methane	19.2494	52.1135	11.973	–11.3173

(e) A combustion chamber is fed with butane and excess air. Combustion of butane is complete. The composition of combustion gases on volume basis is given below :

$CO_2 = 9.39\%$, $H_2O = 11.73\%$, $O_2 = 4.70\%$ and $N_2 = 74.18\%$

Find % Excess air used and mole ratio of air to butane used.

5. Attempt any TWO of the following : **12**

(a) Ethylene oxide is produced by oxidation of ethylene. 100 kmol of ethylene are fed to a reactor and the product is found to contain 80 kmol ethylene oxide and 10 kmol CO_2. Calculate :

(i) The percent conversion of ethylene and

(ii) The percent yield of ethylene oxide.

(b) Calculate the heat of formation of benzoic acid crystals ($C_7H_6O_2$) at 298.15 ºk using following data :

- Standard heat of formation of $CO_2(g) = –393.51$ kJ/mol
- Standard heat of formation of $H_2O(l) = –285.83$ kJ/mol
- Standard heat of combustion of benzoic acid crystals = –3226.95 kJ/mol

(c) A feed to a continuous fractionating column analyses by weight 28 percent benzene and 72 percent toluene. The analysis of the distillate shows 52 weight percent benzene and 5 weight percent benzene was found in the bottom product. Calculate the amount of distillate and bottom product per 1000 kg of feed per hour. Also calculate the percent recovery of benzene.

6. Attempt any TWO of the following : **12**

(a) A coke is known to contain 90% carbon and 10% non-combustible ash (by weight) :

(i) How many moles of oxygen are theoretically required to burn 100 kg of coke completely ?

(ii) If 50% excess air is supplied, calculate the analysis of gases at the end of combustion.

(b) An evaporator is fed with 15000 kg/hr of a solution containing 10% NaC*l*, 15% NaOH and rest water. In the operation, water is evaporated and NaC*l* is precipitated as crystals. The thick liquor leaving the evaporator contains 45% NaOH, 2% NaC*l* and rest water. Calculate

(i) kg/hr water evaporated

(ii) kg/hr salt precipitated

(iii) kg/hr thick liquor

(c) In the manufacture of acetic acid by oxidation of acetaldehyde, 100 kmol of acetaldehyde is fed to reactor per hour. The product leaving the reactor contains 14.81% acetaldehyde, 59.26% acetic acid and rest oxygen (on mole basis). Find the percentage conversion of acetaldehyde.

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