17315

21819

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) 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. (A) Attempt any FOUR of the following : **8**

(i) State Henry's law & Raoult's law.

(ii) Define limiting reactant & excess reactant.

(iii) Define standard heat of formation and standard heat of combustion.

(iv) What is Recycling operation ? State one purpose of recycling operation.

(v) Define partial pressure and pure component volume.

(vi) The carbon monoxide is reacted with hydrogen to produce methanol.

(B) Attempt any TWO of the following : **12**

(i) A mixture of phenol & 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 resp. If 500 kg of phenol & 700 kg of water are mixed and layers allowed to separate, what will be the weights of two layers ?

(ii) Calculate the numbers of cubic metres of acetylene gas at a temperature of 313 °k and pressure of 100 kPa that may be produced from 5 kg of calcium carbide.

(iii) SO_2 is oxidised to SO_3. If the conversion is 70% and air is used in 80% excess than theoretical requirement.

Calculate : (a) kmol of air fed per kmol of SO_2, (b) Composition of gases leaving the reactor on mole basis.

2. Attempt any FOUR : **16**

(i) A combustion reactor is fed with 50 kmol/h of butane and 2100 kmol/h of air. Calculate the % excess of air used.

(ii) State and explain Hess's law of constant heat summation.

(iii) It is desired to make up 1000 kg of solution containing 35% by weight of substance 'A'.

Two solutions are available, one containing 10% by weight A and other containing 50% by weight A.

How many kilograms of each solution will be required ?

(iv) Tray dryer is fed with 1000 kg of wet orthonitro aniline (ONA) containing 10% water. The dried product contains 99.5% ONA and rest water.

Calculate the percentage of original water removed in dryer.

(v) A mixture of CH_4 and C_2H_6 has the average molecular weight of 22.4. Find the mol % of CH_4 & C_2H_6 in mixture.

(vi) A feed containing A, B and inert enters a reactor. The reaction taking place is $2A + B \rightarrow C$. The product leaving the reactor contains 23.08% A, 11.54% B, 46.15% C and 19.23% inert (by mole). Find the analysis of feed on mole basis.

3. Attempt any TWO of the following : **16**

(i) In the manufacture of chlorine, feed containing hydrochloric acid gas and air are fed to an oxidiser. The product gases leaving the oxidiser are found to contain 13.2% HCl, 6.3% O_2, 42.9% N_2, 30% Cl_2 and 7.6% H_2O (by weight).

Calculate : (a) The percent excess air used. (b) Composition of gas mixture entering the oxidiser, by weight.

P.T.O.

(ii) A stream flowing at a rate of 15000 mol/h containing 25 mol% N_2 & 75 mole % H_2 is to be heated from 298 °K to 473 °K.

Calculate the heat that must be transferred, using $C_p°$ data given below :

$C_p° = a + bT + cT^2 + dT^3$, kJ/k mol.K.

Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
N_2	29.5909	– 5.41	13.1829	– 4.968
H_2	28.6105	1.0194	– 0.1476	0.769

(iii) In one case, 26.6 lit of NO_2 at 80 kPa & 298 °K is allowed to stand until the equilibrium is reached. At equilibrium, the pressure is found to be 66.662 kPa. Calculate the partial pressure of N_2O_4 in the final mixture.

The reaction is $2NO_2 \rightarrow N_2O_4$.

4. Attempt any TWO of the following : **16**

(i) The waste acid from a nitrating process contains 30% H_2SO_4, 35% HNO_3 & 35% H_2O by weight. The acid is to be concentrated to contain 39% H_2SO_4 & 42% HNO_3 by adding conc. H_2SO_4 acid containing 98% H_2SO_4 and conc. HNO_3 acid containing 72% HNO_3 (by weight).

Calculate the quantities of acids to be mixed to get 1000 kg of desired mixed acid.

(ii) A feed containing 60 mole % A, 30 mole % B & 10 mole % inerts enters a reactor. The product stream leaving the reactor is found to contain 2 mole % A. The reaction taking place is $2A + B \rightarrow C$.

Find the percentage of original 'A' getting converted to 'C'.

(iii) 10,000 kg/hr of feed containing 20% methanol is continuously fed to a distillation column. Distillate is found to contain 98% methanol and waste solution (bottom product) contains 1% methanol. All percentages are by weight. Calculate : (a) mass flow rates of top & bottom product. (b) Percent loss of methanol.

5. Attempt any TWO of the following : **16**

(i) Centrifuge is fed with a slurry containing 25% solid by weight and wet solid obtained after drying is found to contain 8% moisture by weight and filtrate is found to contain 200 PPm solids.

If centrifuge machine produces 100 kg/h desired wet product and quantity of slurry to be handled is 5000 kg per batch. Calculate : (i) time required for filteration, (ii) Loss of solids in filtrate per batch.

(ii) Pure sulphur is burnt in a sulphur burner with dry air. Oxygen is used 20% excess for complete combustion of sulphur to SO_3. The efficiency of burner is such that only. 30% sulphur is converted to SO_3 and remaining to SO_2. Calculate (a) Composition of gases leavning the burner, (b) The weight of gas per kg of sulphur burnt.

(iii) Calculate the heat that must be removed in cooling 32 kg of oxygen from 488 °K to 313 °K. Using Cp° data.

$Cp° = a + bT + cT^2 + dT^3$ kJ/(kmol. °K)

Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
O_2	26.0257	11.7551	–2.3426	– 0.5623

6. Attempt any FOUR of the following : **16**

(i) Calculate the change in enthalpy between reactants and products if both are at 298 K & if 5 mol of C_2H_4O is produced as per following reaction

$$C_2H_4(g) + \frac{1}{2} O_2 (g) \rightarrow C_2H_4O (g)$$

Data :

Component	ΔH_f°, kJ/mol at 298 K
$C_2H_4(g)$	52.50
$C_2H_4O(g)$	– 52.63

(ii) A natural gas has the following composition by volume. CH_4 – 82%, C_2H_6 – 12% & N_2 – 6%. Calculate the density of gas at 288 k & 101.325 kPa.

(iii) 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 gases leaving the system is found to contain 0.004 kg NH_3 per kg of air. Calculate the percentage recovery of NH_3.

(iv) Ethylene oxide is produced by oxidation of ethylene. 100 kmol of ethylene is fed to reactor and product contains 80 kmol of ethylene oxide & 10 kmol of CO_2. Calculate % conversion of ethylene & % yield of ethylene oxide.

(v) 100 kmol of ethanol are charged to dehydrogenation reactor to produce acetaldehyde. The product stream contains 45 kmol acetaldehyde. Calculate percent conversion of ethanol.

(vi) A wet lumber containing 5% H_2O, is dried to 1% water in a hot air dryer. Air containing 0.5 wt% water is fed to the dryer. The moist air leaving the dryer contains 2% water. Calculate the air required to dry 2000 kg/h of wet lumber.
