17315

15162

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

Instructions : *(1)* ***All*** *questions are* ***compulsory****.*
(2) Illustrate your answers with neat sketches ***wherever*** *necessary.*
(3) Figures to the ***right*** *indicate* ***full*** *marks.*
(4) Assume suitable data, if ***necessary****.*

Marks

1. A) Attempt **any four** of the following : **(2×4=8)**

a) State Dalton's law and Amagats law.

b) Define limiting reactant and excess reactant.

c) State ideal gas law and give its mathematical statement.

d) State Raoult's law and Henry's law.

e) State Hess's law of constant heat summation.

f) Define stoichiometric equation and stoichiometric coefficient.

B) Attempt **any two** of the following : **(6×2=12)**

a) Assuming air to contain 79% N_2 and 21% O_2 by volume. Calculate the density of air at NTP.

b) Calculate the vapour pressure of pure butane at 20° C if its partial pressure is 698 mm Hg in a butane-acetone mixture. The molefraction of acetone in the mixture is 0.577.

c) A gas mixture contains 0.274 Kmol of HCl, 0.337 Kmol of N_2 and 0.089 Kmol of O_2. Calculate (a) Average molecular weight of gas (b) Volume occupied by this mixture at 405.3 KPa and 303 K.

2. Attempt **any four** of the following : **(4×4=16)**

a) Explain general methods for solving material balance problems of systems involving no chemical reaction.

b) Define recycling and state any four reasons for performing recycling operation in industry.

c) A feed containing 60 mole % A, 30 mole % B and 10 mole % inerts enters a reactor. The product stream leaving the reactor is found to contain 2 mole % A. Reaction taking place is $2A + B \rightarrow C$. Find the percentage of original 'A' getting converted to C.

d) In the production of sulphur trioxide, 10 Kmol of SO_2 and 10 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.

P.T.O.

Marks

e) Oxidation of ethylene to produce ethylene oxide is given by the reaction.

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

If air is used 20% in excess of that theoretically required. Calculate the quantity of air supplied based on 100 kmol of ethylene fed to the reactor.

f) A stream of carbon dioxide flowing at a rate of 100 Kmol/min. is heated from 298 K to 383 K. Calculate the heat that must be transferred using Cp°.

Data : $Cp° = a + bT + CT^2 + dT^3$, kJ/(Kmol.K)

Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
CO_2	21.3655	64.2841	– 41.0506	9.7999

3. Attempt **any two** of the following : **(8×2=16)**

a) In the manufacture of chlorine, feed containing hydrochloric acid gas and air are fed an oxidiser. The product gases leaving the oxidises 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) The composition by weight of gases entering the oxidiser

c) The degree of completion of oxidation.

b) In order to carryout nitration reaction, it is desired to have mixed acid containing 39% HNO_3, 42% H_2SO_4 and 19% water by weight. Nitric acid of 68.3% (by weight) is available for this purpose. Calculate (i) strength of sulphuric acid to obtain desired mixed acid. (ii) the weight ratio of HNO_3 to H_2SO_4 acid to be mixed.

c) A feed to a continuous fractionating column analyses by weight 28% benzene and 72% 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.

4. Attempt **any two** of the following : **(8×2=16)**

a) Calculate the heat of reaction at 298.15 K of the following reaction :

$3CaSO_{4(s)} + 3SiO_{2(s)} \rightarrow 3CaO.SiO_{2(s)} + 3SO_{2(g)} + 3O_{2(g)}$

Data :

Component	ΔH_F°, **kJ/mol at 298.15 K**
$CaSO_4(s)$	– 1432.7
$SiO_2(s)$	– 903.5
$CaO.SiO_2(s)$	– 2879
$SO_2(g)$	– 296.81
$O_2(g)$	0.0

Marks

b) Wet solids containing 20% water is sent through a dryer in which 80% of the water is removed. Based on 100 kg of feed, calculate,

a) The mass fraction of dry solids in wet solids that leaves the dryer.

b) The weight ratio of water removed to wet solids leaving the dryer and

c) If 1000 kg per day of wet solids are fed to the dryer. Find the additional water to be removed to dry the solids completely.

c) Monochloroacetic acid ($CH_2ClCOOH$) is manufactured in a semibatch reactor by the action of acetic acid with chlorine using suitable catalyst at 373 K.

$$CH_3COOH + Cl_2 \rightarrow CH_2ClCOOH + HCl$$

The chlorine is used 15% excess (on mole basis) of that theoretically required. The reaction is 95% complete. Calculate the amount of the raw materials required for the production of 3000 Kg of monochlorosacetic acid.

5. Attempt **any two** of the following : **(8×2=16)**

a) A gas containing 25% CO, 5% CO_2, 2% O_2 and rest N_2 by volume is burnt with 25% excess air. If the combustion is 90% complete, calculate the composition by volume of flue gases

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

Calculate :

a) Kg./hr. water evaporated

b) Kg./hr. salt precipitated

c) Kg./hr. thick liquor.

c) Obtain an empirical expression relating the heat of reaction and temperature of the reaction for the following reaction.

$$SO_{2(g)} + \frac{1}{2} O_{2\,(g)} \rightarrow SO_{3(g)}$$

Using the same expression, calculate the heat of reaction at 773 K.

Data :

Component	ΔH_F°, **kJ/Kmol**
$SO_{3(g)}$	– 395720
$SO_{2(g)}$	– 296810

$Cp^\circ = a + bT + CT^2 + dT^3$, kJ/(Kmol.K)

Component	**a**	**b × 10^3**	**c × 10^5**	**d × 10^9**
SO_3	22.036	121.624	– 91.867	24.369
SO_2	24.771	62.948	– 44.258	11.122
O_2	26.026	11.755	– 2.343	– 0.562

Marks

6. Attempt **any four** of the following : **(4×4=16)**

a) A combustion reactor is fed with 50 Kmol/h of butane and 2100 Kmol/hr. of air. Calculate the % excess air used.

b) An aqueous solution of pyridine containing 27% (by weight) and 73% (by weight) water is to be extracted with chlorobenzene. The feed and solvent are mixed well in batch extractor and the mixture is then allowed to stand for phase separation. The extract phase contains 11% pyridine and 88.1% chlorobenzene and 0.9% water by weight. The raffinate phase contains 5% pyridine and 95% water by weight. Calculate (a) The quantities of two phases (layers) (b) The weight ratio of solvent to feed based on 100 kg of feed.

c) After a crystallization operation the solution of calcium chloride in water contains 60 gm of $CaCl_2$ per 100 gm of water. Calculate the amount of this solution necessary to dissolve 200 kg of $CaCl_2.6H_2O$ crystals at a temperature of 298 K. The solubility of $CaCl_2$ at 298 K is 819.2 gm of $CaCl_2$ per 1000 gm of water.

d) In the Decon process for the manufacture of chlorine, a dry mixture of hydrochloric acid gas and air is passed over a heated catalyst which promotes oxidation of acid. Air is used 30% in excess of that theoretically required. Calculate the weight of air supplied per kilogram of the acid. (Atomic wt. of chlorine = 35.5, Air contains 23.2% O_2 by weight)

e) In the manufacture of acetic acid (CH_3COOH) by oxidation of acetaldehyde (CH_3CHO). 100 Kmol of CH_3CHO are fed to a reactor per hour. The product leaving the reactor contains 14.81% CH_3CHO, 59.26% CH_3COOH and rest oxygen (on mole basis) calculate the % conversion of acetaldehyde.

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

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