17315

11819

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

Instructions : *(1)* ***All*** *questions are* ***compulsory****.*
(2) Figures to the ***right*** *indicate* ***full*** *marks.*
(3) Assume suitable data, if ***necessary****.*
(4) Use of Non-programmable Electronic Pocket Calculator is ***permissible****.*
(5) Mobile Phone, Pager and any other Electronic Communication devices are ***not*** *permissible in Examination Hall.*
(6) Use of Steam tables, logarithmic, Mollier's chart is ***permitted****.*

Marks

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

a) State Raoult's law.

b) State Ideal gas law and its mathematical expression.

c) Define yield.

d) State law of conservation of energy.

e) Draw a labelled diagram of crystallisation and an overall material balance equation for the same.

f) Compare sensible heat and latent heat (any two points).

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

a) Assuming air contains 79% N_2 and 21% O_2 by volume, calculate M_{avg} and density of air (Atomic weight of nitrogen = 14 and oxygen = 16).

b) The analysis of gas sample on a mole basis is CH_4 = 66%, CO_2 = 30%, NH_3 = 4%. Calculate the density of the gas sample at a pressure of 304 KPa and at a temperature of 303 K (At. wt. C = 12, H = 1, N = 14 and O = 16)

c) A feed to a continuous fractionating column analyses by weight 30% benzene and 70% toluene. The analysis of the distillate shows 52% benzene and 5 weight % benzene was found in the bottom product. Calculate the amount of distillate and bottom product per 1000 kg of feed per hour.

P.T.O.

Marks

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

a) A sample of gas having volume $1m^3$ is compressed to half of its original volume. The operation is carried for a fixed mass of gas at constant temperature. Calculate the percent increase in pressure.

b) Write down the detail of steps involved in procedure for material balance without chemical reaction calculations.

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

d) Methane gas is heated from 305K to 525K at atmospheric pressure. Calculate the heat added per kmol methane using Cp^o data given below :

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

Gas	a	$b\times10^3$	$c\times10^6$	$d\times10^9$
Methane	19.2494	52.1135	11.973	– 11.3173

e) Calculate the standard heat of reaction of the following reaction.

$C_2H_5OH(g) \rightarrow CH_3CHO(g) + H_2(g)$

Component	ΔH^o_C, KJ/mol
$C_2H_5OH_{(g)}$	– 1410.09
$CH_3CHO_{(g)}$	– 1192.65
$H_{2\ (g)}$	– 285.83

f) Calculate the composition of gases obtained by burning pure FeS_2 with 60% excess air. Assume that reaction proceeds in the following manner and goes to completion.

$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$

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

a) An evaporator system containing a weak liquor from 5% to 50% solids handles 1.00 kg of solids per hour. If the same system is to concentrate a weak liquor from 4% to 35%. Find the capacity of the system in terms of solids that can be handled per hour assuming water evaporation capacity to be same in both the cases.

b) A waste acid from a nitrating process contains 23% HNO_3, 57% H_2SO_4 and 20% water by weight. This acid is to be concentrated to contain 27% HNO_3, 60% H_2SO_4 by the addition of concentrated H_2SO_4 containing 93% H_2SO_4 and conc. HNO_3 containing 90% HNO_3. Calculate the amounts in kg of waste and concentrated acids that must be combined to obtain 1000 kg of desired mixture.

Marks

c) In the manufacture of chlorine, feed containing HCl 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) the composition by weight of gases entering the oxidiser c) the degree of completion of oxidation.

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

a) Flue gases leaving the boiler stack at 523K have the following composition :

CO_2 = 11.31%, H_2O = 13.04%, O_2 = 2.17%, N_2 = 73.48% (by volume).

Calculate the heat lost in 1 kmol of the gas above 298K using the heat capacity data given below :

$Cp^o = a + bT + cT^2 + dT^3$ (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
H_2O	32.4921	0.0796	13.2107	– 4.5474
O_2	26.0257	11.7551	– 2.3426	– 0.5623
N_2	29.5909	– 5.141	13.1829	– 4.968

b) 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.

c) 10000 kg/h of solution containing 20% methanol is continuously fed to a distillation column. Distillate (Product) is found to contain 98% methanol and waste solution from the column carries 1% methanol. All percentages are by weight. Calculate : a) the mass flow rates of distillate and bottom product and b) the percent loss of methyl alcohol.

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

a) A feed containing A, B and inerts enters a reactor. The reaction taking place is $2A + B \rightarrow C$. The product stream leaving the reactor is having the following composition by mole. A = 23.08%, B = 11.54%, C = 46.15% and inerts = 19.23%. Find the analysis of feed on mole basis.

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.

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

c) The ammonia is produced by the following reaction.

$N_2 + 3H_2 \rightarrow 2NH_3$

Calculate :

a) The molal flow rate of hydrogen corresponding to nitrogen feed rate of 25 kmol/h if they are fed in the stoichiometric proportion.

b) The kg of ammonia produced per hour if percent conversion is 25% and nitrogen feed rate is 25 kmol/h.

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

a) Calculate the volume occupied by 20kg of chlorine gas at pressure of 100 KPa and 298 K.

b) The groundnut seeds containing 45% oil and 45% solids are fed to an expeller, the coke coming out of expeller is found to contain 80% solids and 5% oil. Find the percent recovery of oil.

c) In the production of SO_3, 100 kmol of SO_2 and 200 kmol of O_2 are fed to a reactor. The product stream is found to contain 80 kmol SO_3. Find the percent conversion of SO_2.

d) What is Hess's law of constant heat summation ? Explain with example.

e) Calculate the standard heat formation of n-propanol liquid using the following data :

$\Delta Hf_{CO_2(g)} = -393.51$ kJ/mol, $\Delta Hf_{H_2O(l)} = -285.83$ kJ/mol,

$\Delta Hc_{\text{n-propanol}} = -2028.19$ kJ/mol.

f) The Henry's law constant for CO_2 in water at 313K is 7.05×10^8 kPa/mole fraction. Find the partial pressure of CO_2 in the gas phase if x_{CO_2} is 4.2×10^{-6}.
