



17315

11819

3 Hours / 100 Marks

Seat No.

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- 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% N₂ and 21% O₂ 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 CH₄ = 66%, CO₂ = 30%, NH₃ = 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
(4×4=16)

2. Attempt **any four** :

- 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.
- Write down the detail of steps involved in procedure for material balance without chemical reaction calculations.
- A combustion reactor is fed with 50kmol/h of butane and 2100 kmol/h of air. Calculate the % excess air used.
- Methane gas is heated from 305K to 525K at atmospheric pressure. Calculate the heat added per kmol methane using C_p° data given below :

$$C_p^\circ = a + bT + cT^2 + dT^3 \text{ kJ}/(\text{kmol}\cdot\text{K})$$

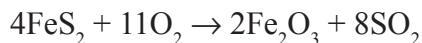
Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
Methane	19.2494	52.1135	11.973	- 11.3173

- Calculate the standard heat of reaction of the following reaction.



Component	ΔH_c° , KJ/mol
$\text{C}_2\text{H}_5\text{OH}_{(\text{g})}$	- 1410.09
$\text{CH}_3\text{CHO}_{(\text{g})}$	- 1192.65
$\text{H}_2_{(\text{g})}$	- 285.83

- 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.



3. Attempt **any two** of the following :

(8×2=16)

- 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.
- 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% O₂, 42.9% N₂, 30% Cl₂ and 7.6% H₂O (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 :

CO₂ = 11.31%, H₂O = 13.04%, O₂ = 2.17%, N₂ = 73.48% (by volume).

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

$$C_p^0 = a + bT + cT^2 + dT^3 \text{ (kJ/kmol.K)}$$

Gas	a	b × 10 ³	c × 10 ⁶	d × 10 ⁹
CO ₂	21.3655	64.2841	- 41.0506	9.7999
H ₂ O	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)
- How many moles of oxygen are theoretically required to burn 100 kg of coke completely ?
 - 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.

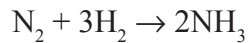
5. Solve **any two** of the following :

(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
- The mass fraction of dry solids in wet solids that leaves the dryer.
 - The weight ratio of water removed to wet solids leaving the dryer.
 - 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) The ammonia is produced by the following reaction.



Calculate :

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

- Calculate the volume occupied by 20kg of chlorine gas at pressure of 100 KPa and 298 K.
 - The groundnut seeds containing 45% oil and 45% solids are fed to an expeller, the cake coming out of expeller is found to contain 80% solids and 5% oil. Find the percent recovery of oil.
 - 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 .
 - What is Hess's law of constant heat summation ? Explain with example.
 - Calculate the standard heat formation of n-propanol liquid using the following data :

$$\Delta H_f^{\text{CO}_2(\text{g})} = -393.51 \text{ kJ/mol}, \Delta H_f^{\text{H}_2\text{O}(\text{l})} = -285.83 \text{ kJ/mol},$$

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