

313336

12526

3 Hours / 70 Marks

Seat No.

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- Instructions* –
- (1) All Questions are *Compulsory*.
 - (2) Answer each next main Question on a new page.
 - (3) Illustrate your answer with neat sketches wherever necessary.
 - (4) Figures to the right indicate full marks.
 - (5) Assume suitable data, if necessary.
 - (6) Use of Non-programmable Electronic Pocket Calculator is permissible.
 - (7) 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) State Dalton's law and write mathematical equation.
 - b) State Raoult's law and Henry's law.
 - c) Write material balance equation for distillation with block diagram.
 - d) Define limiting reactant and excess reactant.
 - e) Define sensible heat and latent heat.
 - f) State different types of fuel with examples.
 - g) Define Gross calorific value and Net calorific value.

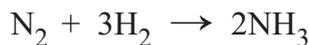
P.T.O.

2. Attempt any THREE of the following:

12

- a) Derive the expression for density of a gas mixture.
- 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 :-
- kg/h water evaporated
 - kg/h salt precipitated
 - kg/h thick liquor.

- c) Ammonia is produced by the following reaction:



Calculate :-

- The molal flow rate of hydrogen corresponding to nitrogen feed rate of 25 kmol/hr 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/hr.
- d) A stream of nitrogen flowing at a rate of 100 kmol/h is heated from 303 K (30°C) to 373 K (100°C).

Calculate the heat that must be transferred.

Data: $[\text{Cp}^\circ \text{ for nitrogen} = 29.5909 - 5.141 \times 10^{-3}T + 11.1829 \times 10^{-6} T^2 - 4.968 \times 10^{-9} T^3]$

3. Attempt any THREE of the following:

12

- A pressure gauge on a tower indicates a vacuum of 3.53 in Hg. The barometric pressure is 29.31 in Hg. Find the absolute pressure in the tower in mm Hg. (in Hg means inches of Hg)
- The dilute acid containing 25% H_2SO_4 is concentrated by commercial grade sulphuric acid containing 98% H_2SO_4 to obtain desired acid containing 65% H_2SO_4 . Find the quantities of the acids required to make 1000 kg of desired acid.
- In the 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 the mole basis.

- d) Calculate the heat that must be removed in cooling 32 kg of oxygen from 488 k (215°C) to 313 k (40°C) using C_p° .

Data: $C_p^\circ = a + bT + cT^2 + dT^3$, 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

4. Attempt any THREE of the following:

12

- a) A mixture of CH₄ and C₂H₆ has the average molecular weight of 22.4. Find mole % CH₄ and C₂H₆ in mixture.
- b) 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.
- c) A combustion reactor is fed with 50 kmol/h of butane and 2100 kmol/h of air. Calculate the % excess air used.
- d) Calculate the heat needed to raise the temperature of 1 kmol of ammonia from 311 k to 422 k using the mean molal heat capacity.

Data:

$C_{p,m}^\circ$ for NH₃ between 311 k and 298 k = 35.8641 kJ/kmol.k

$C_{p,m}^\circ$ for NH₃ between 422 k and 298 k = 37.7063 kJ/kmol.k

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

Standard heat of formation of CO₂(g) = -393.51 kJ/mol

Standard heat of formation of H₂O (l) = -285.83 kJ/mol

Standard heat of combustion of n-propanol liquid = -2028.19 kJ/mol

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

- a) A gas mixture has the following composition by volume :-

$$\text{SO}_2 = 8.5\%, \text{O}_2 = 10\% \text{ and } \text{N}_2 = 81.5\%$$

Find:

- i) The density of gas mixture at a temperature of 473 k and 303.975 kPa and
 - ii) Composition by weight.
- b) A gas mixture containing 15 mole % A and 85 mole % inerts is fed to an absorption tower where it is contacted with liquid solvent 'B' which absorbs 'A'. The mole ratio of solvent to gas entering tower is 2:1. The gas leaving the absorber contains 2.5% A, 1.5% B and rest inerts (on mole basis).

Find :-

- i) The percent recovery of solute 'A'
- ii) The fraction of solvent 'B' fed to the column lost in gas leaving the tower.

Note that during the process, some solvent evaporates and gets added in the gas leaving the tower.

- c) 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.

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

- a) The spent acid from a nitrating process contains 21% HNO_3 , 55% H_2SO_4 and 24% H_2O by weight. This acid is to be concentrated to contain 28% HNO_3 and 62% H_2SO_4 by addition of concentrated sulphuric acid containing 93% H_2SO_4 and concentrated nitric acid containing 90% HNO_3 . Calculate the weights of spent acid concentrated sulphuric acid and concentrated nitric acid that must be combined to obtain 1000 kg of the desired mixture.

- b) The carbon monoxide is reacted with hydrogen to produce methanol. Calculate from the reaction :-
- The stoichiometric ratio of H_2 to CO.
 - kmol of CH_3OH produced per kmol CO reacted.
 - The weight ratio of CO to H_2 if both are fed to reactor in stoichiometric proportion.
 - The quantity of CO required to produce 1000 kg of CH_3OH .
- c) Calculate the net calorific value (NCV) at 298 k of a sample of fuel oil having C/H ratio 9.33 (by weight) and containing sulphur to the extent of 1.3% by weight.

Data:

The GCV of the fuel oil at 298 k = 41785 kJ/kg.

Latent heat of water vapour at 298 k = 2442.5 kJ/kg
