

17315

11920

3 Hours / 100 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 answers 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. (A) Answer any FOUR :

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- (a) Give the expression for ideal gas law. Explain the terms involved.
- (b) Define limiting component and excess component.
- (c) Give the value of R in S.I.
- (d) Define Amagat's law with mathematical expression.
- (e) Define :
 - (i) Adiabatic reaction
 - (ii) Adiabatic reaction temperature
- (f) Define :
 - (i) % conversion
 - (ii) % yield

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(B) Answer any TWO :

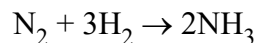
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- (a) A natural gas has the following composition by volume : $\text{CH}_4 = 82\%$, $\text{C}_2\text{H}_6 = 12\%$, $\text{N}_2 = 6\%$. Calculate :
- density of gas at 288 K & 101.325 KPa
 - Composition in weight %
- (b) A gas contained in a closed vessel at a pressure of 121.59 KPa g and 299 K (26°C) is heated to a temperature of 127. K (100°C). Find the pressure to which a closed vessel should be designed.
- (c) The Henry's law constant for CO_2 in water at 313 K is 7.05×10^6 KPa/mol fractions. Find partial pressure of CO_2 in the gas phase if mol fraction of CO_2 dissolved in liquid is 4.2×10^{-6} .

2. Attempt any FOUR :

16

- (a) A single effect evaporator concentrating a weak liquor containing 4% solids to 55% solids (by weight) is fed with 5000 kg/hr of weak liquor. Calculate :
- water evaporated per hour
 - flow rate of thick liquor
- (b) 2000 kg of wet solids containing 70% solids by weight are fed to tray dryer where it is dried by hot air. The product finally obtained is found to contain 1% moisture by weight. Calculate :
- kg of water removed from wet solids.
 - kg of product obtained.
- (c) Ammonia is produced by following reaction :



Calculate :

- The molal flow rate of hydrogen corresponding to nitrogen feed rate of 25 k mol/hr, if they are fed in the stoichiometric proportion.
- The kg of ammonia produced per hour if % conv. is 25 and nitrogen feed rate is 25 k mol/hr.

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- (d) In production of SO_3 , 200 k/moles of SO_2 and 400 k/moles of O_2 are fed to reactor. The product stream is found to contain 150 k/moles SO_3 . Find % conversion of SO_2 .
- (e) A combustion reactor is fed with 50 k/moles of butane and 2100 k/moles of air/hr. Calculate the % excess air used.
- (f) At what rate in kcal/hr heat must be transferred to liquid $\text{C}_2\text{H}_5\text{OH}$ at its boiling point to generate 100 kg/hr of $\text{C}_2\text{H}_5\text{OH}$ vapour ? $\lambda = 202$ kcal/kg.

3. Attempt any TWO :

16

- (a) Ethylene oxide is produced by the oxidation of ethylene. 100 k/moles of ethylene fed to a reactor and product is found to contain 75 k/moles $\text{C}_2\text{H}_4\text{O}$ and 10 k/moles CO_2 . Calculate :
- (i) % conversion of ethylene
- (ii) % yield of $\text{C}_2\text{H}_4\text{O}$
- (b) The feed containing 50% benzene and 50% toluene is fed to a distillation column at a rate of 5000 kg/hr. A top product contains 95% benzene and bottom product contains 92% toluene (by weight). Calculate :
- (i) the mass flow rate of top and bottom products
- (ii) % recovery of benzene
- (c) Centrifuge is fed with a slurry containing 25% solids. Wet solids obtained after filtration are analysed to contain 8% moisture by weight and filtrate is found to contain 200 ppm solids. If machine produces 100 kg/hr desired wet product and quantity of slurry to be handled is 5000 kg/batch, calculate :
- (i) time required for filtration of slurry
- (ii) loss of solids in filtrate per batch

4. Attempt any TWO :

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- (a) Calculate the heat of formation of liquid 1-3 butadiene (C_4H_6) at 298.15 K using following data :
- Std. heat of formation of $\text{CO}_{2(g)} = -393.51$ kJ/mol
- Std. heat of formation of $\text{H}_2\text{O}_{(l)} = -285.83$ kJ/mol
- Heat of combustion of $\text{C}_4\text{H}_{6(l)} = -2520.11$ kJ/mol

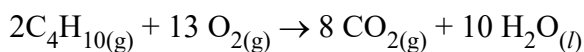
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- (b) The waste acid from a nitrating process containing 20% HNO_3 , 55% H_2SO_4 and 25% H_2O by weight is to be concentrated by addition of con. H_2SO_4 containing 95% H_2SO_4 and conc. HNO_3 containing 90% HNO_3 to get desired mixed acid containing 26% HNO_3 , 60% H_2SO_4 . Calculate the quantities of waste and concentrated acids required for 1000 kg of desired mixed acid.
- (c) SO_2 is oxidised to SO_3 . If % conversion is 70 and air is used 80% in excess over theoretical requirement, calculate :
- k/moles of air fed per k/mole SO_2
 - Composition of gas leaving reactor on volume basis

5. Attempt any TWO :

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- (a) The feed containing 60 mol % A, 30 mol % B and 10 mol % inert enters a reactor. The product stream leaving the reactor is found to contain 2 mol % A. The reaction taking place is $2\text{A} + \text{B} \rightarrow \text{C}$. Find % of original A getting converted to C.
- (b) A feed stream to a process is to consist of 500 kg/hr of a gas containing 30 mol % N_2 and 70 mol % H_2 . The stream is obtained by blending gases from two tanks, both tanks contain $\text{H}_2 - \text{N}_2$ mixture. Tank 1 contains 10% N_2 and tank 2 contains 50% N_2 (% are by volume). Calculate the required flow rates of gas mixture from tank 1 and tank 2.
- (c) Calculate the enthalpy change between reactants and products if both are at 298.15 K and if 60 mol of CO_2 is produced according to the reaction



Component	ΔH°_f kJ/mol at 298.15 K
$\text{C}_4\text{H}_{10(\text{g})}$	-125.79
$\text{CO}_{2(\text{g})}$	-393.51
$\text{H}_2\text{O}_{(\text{l})}$	-285.83

6. Attempt any FOUR :

- (a) In manufacture of SO_3 feed to reactor consists of 50 k/mol SO_2 and 150 k/mol air. Calculate % excess air used over theoretical requirement.
- (b) 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 gas leaving the system is found to contain 0.004 kg NH_3 per kg air. Find % recovery of ammonia.
- (c) A sample of coal is found to contain 63% C and 24% ash on weight basis. The analysis of refuse after combustion shows 7% C and rest ash. Calculate % of original C unburnt in the refuse.
- (d) For the manufacture of Cl_2 , a dry mixture of HCl gas and air is passed over a heated catalyst which promotes oxidation of acid. Air is used 30% excess of that theoretically required. Calculate the weight of air supplied per kg acid.
- (e) Formaldehyde is produced from CH_3OH in catalytic reactor. The production rate of HCHO is 1000 kg/hr. If the conversion of methanol is 65%, calculate the required feed rate of methanol.
- (f) Calculate the heat that must be transferred to 3 k/mol air to heat it from 25°C to 200°C using mean molal heat capacity data for oxygen. CP_m^0 (between 200°C and 25°C) for air = 29.3955 kJ/(k/mol·k)
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