

17315

13141

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) **Attempt any FOUR of the following:** **08**
- i) State the Vander Waal's equation used for real gases.
 - ii) Define yield and conversion.
 - iii) Define average molecular weight of a gas mixture and give an expression for its determination.
 - iv) State Henry's law for gas-Liquid system.
 - v) Define standard heat of formation.
 - vi) What do you mean by percent excess?

P.T.O.

b) Attempt any **TWO** of the following:

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- i) A gas mixture has the following composition by volume.
Ethylene (C_2H_4) 30.6%, Benzene (C_6H_6) 24.5%,
Oxygen (O_2) 1.3%, Methane (CH_4) 15.5%,
Ethane (C_2H_6) 25.0%, Nitrogen (N_2) 3.1%

Find :

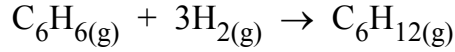
- 1) The average molecular weight of the gas mixture.
 - 2) The density of the mixture in Kg/m^3 at 273.15 K and 101.325 KPa.
- ii) Calculate the vapour pressure of pure butane at $20^\circ C$ if its partial pressure is 698 mm Hg in a butane-acetone mixture. The mole fraction of acetone in the mixture is 0.577.
- iii) A sample of gas having volume of $1m^3$ 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.

2. Attempt any **FOUR** of the following:

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- a) Explain the steps for solving material balance problems without chemical reaction.
- b) A sample of coal is found to contain 63% carbon and 24% ash on a weight basis. The analysis of refuse after combustion shows 7% carbon and rest ash. Calculate the percentage of the original carbon unburnt in the refuse.
- c) Formaldehyde is produced from methanol in a catalytic reactor. The production rate of formaldehyde is 1000 Kg/hr. If the conversion of methanol is 65%. Calculate the required feed rate of methanol.

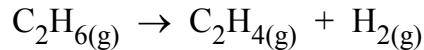
- d) Gaseous benzene (C_6H_6) reacts with hydrogen in the presence of Ni catalyst as per the reaction



30% excess hydrogen is used above that required by the above reaction. Conversion is 50% and yield is 90%.

Calculate the requirement of benzene and hydrogen gas for 100 moles of cyclohexane.

- e) In production of sulphur trioxide 100 kmol of SO_2 and 200 kmol 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 .
- f) Calculate the heat of reaction at 298.15 k (25°C) of the following reaction.

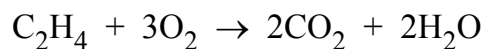
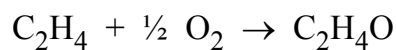


Component	ΔH_c (KJ/mol)
$C_2H_{6(g)}$	-1560.69
$C_2H_{4(g)}$	-1411.2
$H_{2(g)}$	- 285.83

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

16

- a) Ethylene oxide is prepared by oxidation of ethylene. 100 kmol of ethylene and 100 kmol of O_2 are charged to a reactor. The percent conversion of ethylene is 85% and percent yield of C_2H_4O is 94.12%. Calculate the composition of product stream leaving the reactor. The reactions taking place are



- 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 concentrated sulphuric acid containing 95% H_2SO_4 and concentrated nitric acid containing 90% HNO_3 to get desired mixed acid containing 26% HNO_3 and 60% H_2SO_4 . Calculate the quantities of waste acid and concentrated acids required for 1000 kg of desired mixed acid.
- c) 10,000 kg/hr 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 :
- The mass flow rates of distillate and bottom product.
 - The percent loss of methanol.

4. Attempt any TWO of the following:

16

- a) Calculate the standard heat of formation of naphthalene (C_{10}H_8) crystals from its elements at 298.15 k using the following data.
- Data : Standard heat of formation of $\text{CO}_{2(g)} = -393.51$ KJ/mol
Standard heat of formation of $\text{H}_2\text{O}(l) = -285.83$ KJ/mol
Heat of combustion of naphthalene (C_{10}H_8) at 298.15 k = 5156.95 KJ/mol
- b) 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

- c) A feed containing A, B and inerts enters a reactor.
The reaction taking place is



The product stream leaving the reactor is having following composition by mole. inerts = 19.23%, A = 23.08%, B = 11.54%, C = 46.15%

Find the analysis of feed on mole basis.

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

16

- a) Calculate the composition of gases obtained by burning pure FeS₂ with 60% excess air. Assume that reaction proceeds in the following manner and goes to completion.



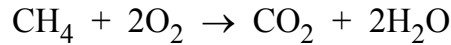
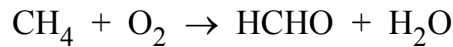
- b) Dryer system handles 1000 kg/day of wet solids. Wet solids containing 50% solids and 50% water are fed to the first dryer. From the first dryer the product that comes out has 20% moisture. This is admitted to the second dryer, from which the product coming out has 2% moisture. Calculate the % of original water that is removed in each dryer and final weight of the product.
- c) Methane gas is heated from 303k to 523k at atmospheric pressure. Calculate the heat added per kmol methane using Cp° data given below

Data : Cp° = a + bT + cT² + dT³, (kJ/kmol.k)

Gas	a	b × 10 ³	c × 10 ⁶	d × 10 ⁹
Methane	19.2494	52.1135	11.973	-11.3173

6. Attempt any FOUR of the following:**16**

- a) Methane oxidation reactions are :



100 kmol of methane are charged, if the product stream is found to contain 10 kmol CO_2 and 40 kmol formaldehyde. Calculate.

- i) The percent conversion of methane and
 - ii) The yield of formaldehyde
- b) The ground nuts seeds containing 45% oil and 45% solids are fed to expeller, the cake coming out of expeller is found to contain 80% solid and 5% oil. Find the percentage recovery of oil.
- c) Define recycling and state any four reasons for performing recycling operation in industry.
- d) A coke is known to contain 90% carbon and 10% ash by weight. Air is used 20% excess for combustion (on mole basis). Calculate the moles of air supplied per 100 kg of coke burned.
- e) 100 kmol of ethanol are charged to a dehydrogenation reactor to produce acetaldehyde (CH_3CHO). The product stream is found to contain 45 kmol acetaldehyde. Find the percent conversion of ethanol.
- f) Explain Hess's law of constant heat summation with example.
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