17315

13141

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

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 <u>FOUR</u> 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?

Marks

b) **Attempt any <u>TWO</u> of the following:** **12**

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°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 <u>FOUR</u> of the following: **16**

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.

Marks

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

$C_6H_{6(g)} + 3H_{2(g)} \rightarrow C_6H_{12(g)}$

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.

$C_2H_{6(g)} \rightarrow C_2H_{4(g)} + H_{2(g)}$

Component	Δ Hc (KJ/mol)
$C_2H_{6(g)}$	–1560.69
$C_2H_{4(g)}$	–1411.2
$H_{2(g)}$	– 285.83

3. Attempt any <u>TWO</u> 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

$C_2H_4 + ½\ O_2 \rightarrow C_2H_4O$

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

Marks

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 :

i) The mass flow rates of distillate and bottom product.

ii) The percent loss of methanol.

4. Attempt any <u>TWO</u> of the following: **16**

a) Calculate the standard heat of formation of napthalene ($C_{10}H_8$) crystals from its elements at 298.15 k using the following data.

Data : Standard heat of formation of $CO_{2(g)}$ = –393.51 KJ/mol
Standard heat of formation of $H_2O(l)$ = –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 :

i) Water evaporated per hour

ii) Flow rate of thick liquor

Marks

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

$2A + B \rightarrow C$

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 <u>TWO</u> of the following: **16**

a) 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.

$4FeS_{2(s)} + 11\ O_{2(g)} \rightarrow 2FeO_{3(s)} + 8\ SO_{2(g)}$

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 : $Cp° = a + bT + cT^2 + dT^3$, (kJ/kmol.k)

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

Marks

6. Attempt any <u>FOUR</u> of the following: **16**

a) Methane oxidation reactions are :

$CH_4 + O_2 \rightarrow HCHO + H_2O$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

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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