17315

16117

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

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) Solve **any four** of the following : **(2×4=8)**

a) Define sensible heat and heat capacity.

b) State law of conservation of mass.

c) What is the value of universal gas constant 'R' when expressed in

$\frac{\text{Kcal}}{(\text{Kmol.K})}$ and $\text{J}/(\text{mol.K})$

d) What is stoichiometric ratio for the reaction $CO + 2H_2 \rightarrow CH_3OH$.

e) For ideal gases ideal gas law is applicable, similarly state the law applicable for real gases.

f) State law of conservation of energy.

B) Solve **any two** of the following : **(6×2=12)**

a) A feed containing 60 mole % A, 30 mole % B and 10 mole % inerts enters a reactor, 80% of original A reacts according to the following reaction.

$2A + B \rightarrow C$. Find the composition of the product stream on mole basis.

b) A feed to a continuous fractionating column analyses by weight 28% benzene and 72% toluene. The analysis of the distillate shows 52 weight % benzene and 5 weight % benzene was found in the bottom product. Calculate the amount of distillate and product per 1000 kg of feed per hour.

c) Chlorine is produced by reaction $4HCl + O_2 \rightarrow 2Cl_2 + 2H_2O$. Air is used 30% in excess of that theoretically required. Calculate the weight of air supplied per kilogram of the acid.

P.T.O.

Marks

2. Solve **any four** of the following : **(4×4=16)**

a) Formaldehyde is produced from methanol in a catalytic reactor. The production rate of formaldehyde is 1000 kg/h. If the conversion of methanol is 65% calculate the required feed rate of methanol.

b) State and explain Hess's law of constant heat summation.

c) The combustion of 4.73 kg of a sample of coal yielded 5.30 m^3 of carbon dioxide gas measured at N.T.P. Find the carbon content of the sample.

d) 2000 kg of wet solids containing 70% solids by weight are fed to a tray dryer where it is dried by hot air. The product finally obtained is found to contain 1% moisture by weight. Calculate :

a) The kg of water removed from wet solids

b) Kg of product obtained.

e) A cylinder contains 15 kg of liquid propane. What volume in m^3 will propane occupy if it is released and brought to N.T.P. conditions ?

f) Calculate the standard heat of reaction of the following reaction.

$C_5H_{12\,(l)} + 8O_{2(g)} \rightarrow 5CO_{2(g)} + 6H_2O_{(l)}$

Data component	$\Delta H_f^\circ, \frac{KJ}{mol}$ at 298.15 K
$C_5H_{12\,(l)}$	– 173.49
$CO_{2(g)}$	– 393.51
$H_2O_{(l)}$	– 285.83

3. Solve **any four** of the following : **(4×4=16)**

a) A sample of gas having volume of 1 m^3 is compressed in such a manner so that its pressure is increased by 85%. The operation is done for a fixed mass of gas at constant temperature. Calculate the final volume of gas.

b) Methane gas is heated from 303 K to 523 K at atmospheric pressure. Calculate the heat added per Kmol methane using Cp° data given below.

Data $Cp^\circ = a + bT + cT^2 + dT^3$, $\frac{KJ}{(Kmol.K)}$.

Gas	a	$b\times10^3$	$c\times10^6$	$d\times10^9$
CH_4	19.2494	52.1135	11.973	–11.3173

c) 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.

Marks

d) Ammonia is produced by the following reaction

$N_2 + 3H_2 \rightarrow 2NH_3$.

Calculate :

a) Molal flow rate of hydrogen corresponding to nitrogen feed rate of 25 Kmol/h if they are fed in stoichiometric proportion.

b) The kg of ammonia produced per hour if percent conversion is 25 and nitrogen feed rate is 25 Kmol/h.

e) Calculate the heat needed to raise the temperature of 1 Kmol of ammonia from 311 K to 422 K using mean molal heat capacity.

Data : Cp°m for NH_3 between 311K to 298K = 35.8641 $\frac{KJ}{(Kmol.K)}$ Cp°m for NH_3 between 422 K to 298 K = 37.7063 $\frac{KJ}{(Kmol.K)}$.

f) Assuming air to contain 79% N_2 and 21% O_2 by volume, calculate the density of air at N.T.P.

4. Solve **any two** of the following : **(8×2=16)**

a) The average molecular weight of a flue gas sample is calculated by two different engineers. One engineer uses the correct molecular weight of 28 for N_2 and determines the average molecular weight to be 30.08, the other engineer uses an incorrect value of 14 and calculate the average molecular weight to be 18.74. Calculate :

i) The volume % of N_2 in the flue gases.

ii) If the remaining component of the flue gases are CO_2 and O_2, find the volume % of each of them.

b) A mixture of nitrogen and carbon dioxide at 298 K and 101.325 Kpa has an average molecular weight of 31. Find the partial pressure of nitrogen.

c) Soya bean seeds are extracted with hexane in batch extractors. The flaked seeds are found to contain 18.6% oil, 69% solids and 12.4% moisture (by weight). At the end of the extraction process, cake is separated from hexane-oil mixture. The cake is analysed to contain 0.8% oil, 87.7%. solids and 11.5% moisture (by weight). Find the percentage recovery of oil.

5. Solve **any two** of the following : **(8×2=16)**

a) A Coke is known to contain 90% carbon and 10% non-combustible ash (by weight).

a) How many moles of oxygen are theoretically required to burn 100 kg of coke completely ?

b) If 50% excess air is supplied, calculate the analysis of gases at the end of combustion.

b) A stream flowing at a rate of 15000 mol/h containing 25 mole % N_2 and 75 mole % H_2 is to be heated from 298 K to 473 K. Calculate the heat that must be transferred using Cp° data given below :

$Cp° = a + bT + cT^2 + dT^3$, KJ/(Kmol.K)

Gas	a	$b\times10^3$	$c\times10^6$	$d\times10^9$
N_2	29.5909	– 5.41	13.1829	– 4.968
H_2	28.6105	1.0194	–0.1476	0.769

Marks

c) A sample of petrol contains 15% H_2 and 85% C by weight. Calculate the amount of air required for the complete combustion of 1 kg of petrol. Find the composition of the dry products on a volume basis if 15% excess air is supplied.

6. Solve **any two** of the following : **(8×2=16)**

a) The waste acid from nitrating process containing 20% HNO_3, 55% H_2SO_4 and 25% H_2O by weight is to be concentrated by addition of concentrated sulfuric 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 and concentrated acids required for 1000 kg of desired mixed acid.

b) Benzene reacts with nitric acid to produce nitrobenzene and water

$$C_6H_6 + HNO_3 \xrightarrow{H_2SO_4} C_6H_5NO_2 + H_2O \ldots (1)$$

Nitrobenzene formed may undergo further nitration to form dinitrobenzene

$$C_6H_5\ NO_2 + HNO_3 \xrightarrow{H_2SO_4} C_6H_4(NO_2)_2 + H_2O \ldots (2)$$

The % conversion of benzene is 90 and acid is used 65% excess over theoretical requirement by reaction (1), if the mole ratio of nitrobenzene to dinitrobenzene in product stream is 17 : 1. Calculate the quantities of benzene and nitric acid required for production of 2000 kg/h of nitrobenzene.

c) Dryer system handles 1000 kg/day of wet solids. Wet solids containing 50% solids and 50% water are fed to the first dryer and 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.