



17315

16117

3 Hours / 100 Marks

Seat No.

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- 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 $\frac{\text{J}}{(\text{mol.K})}$
- d) What is stoichiometric ratio for the reaction $\text{CO} + 2\text{H}_2 \rightarrow \text{CH}_3\text{OH}$.
- 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.
 $2\text{A} + \text{B} \rightarrow \text{C}$. 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 $4\text{HCl} + \text{O}_2 \rightarrow 2\text{Cl}_2 + 2\text{H}_2\text{O}$. Air is used 30% in excess of that theoretically required. Calculate the weight of air supplied per kilogram of the acid.

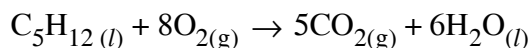
P.T.O.



2. Solve **any four** of the following :

(4×4=16)

- 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.
- State and explain Hess's law of constant heat summation.
- The combustion of 4.73 kg of a sample of coal yielded 5.30 m³ of carbon dioxide gas measured at N.T.P. Find the carbon content of the sample.
- 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 :
 - The kg of water removed from wet solids
 - Kg of product obtained.
- A cylinder contains 15 kg of liquid propane. What volume in m³ will propane occupy if it is released and brought to N.T.P. conditions ?
- Calculate the standard heat of reaction of the following reaction.



Data component $\Delta H_f^\circ, \text{KJ/mol}$ at 298.15 K

$\text{C}_5\text{H}_{12(l)}$ - 173.49

$\text{CO}_{2(g)}$ - 393.51

$\text{H}_2\text{O}_{(l)}$ - 285.83

3. Solve **any four** of the following :

(4×4=16)

- A sample of gas having volume of 1 m³ 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.
- Methane gas is heated from 303 K to 523 K at atmospheric pressure. Calculate the heat added per Kmol methane using C_p° data given below.

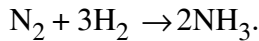
Data $C_p^\circ = a + bT + cT^2 + dT^3, \text{KJ}/(\text{Kmol.K})$.

Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
CH ₄	19.2494	52.1135	11.973	-11.3173

- 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.



d) Ammonia is produced by the following reaction



Calculate :

- Molal flow rate of hydrogen corresponding to nitrogen feed rate of 25 Kmol/h if they are fed in stoichiometric proportion.
 - 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 : C_p° for NH_3 between 311K to 298K = $35.8641 \frac{\text{KJ}}{(\text{Kmol.K})}$ C_p° for NH_3 between

422 K to 298 K = $37.7063 \frac{\text{KJ}}{(\text{Kmol.K})}$.

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)

- 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 :
 - The volume % of N_2 in the flue gases.
 - If the remaining component of the flue gases are CO_2 and O_2 , find the volume % of each of them.
- 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.
- 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 Coke is known to contain 90% carbon and 10% non-combustible ash (by weight).
 - How many moles of oxygen are theoretically required to burn 100 kg of coke completely ?
 - If 50% excess air is supplied, calculate the analysis of gases at the end of combustion.
- 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 C_p° data given below :

$$C_p^\circ = a + bT + cT^2 + dT^3, \text{ KJ}/(\text{Kmol.K})$$

Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
N_2	29.5909	- 5.41	13.1829	- 4.968
H_2	28.6105	1.0194	-0.1476	0.769



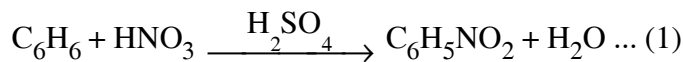
Marks

- c) A sample of petrol contains 15% H₂ 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.

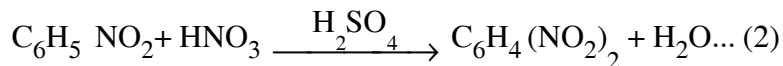
6. Solve **any two** of the following :

(8×2=16)

- a) The waste acid from nitrating process containing 20% HNO₃, 55% H₂SO₄ and 25% H₂O by weight is to be concentrated by addition of concentrated sulfuric acid containing 95% H₂SO₄ and concentrated nitric acid containing 90% HNO₃ to get desired mixed acid containing 26% HNO₃ and 60% H₂SO₄. 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



Nitrobenzene formed may undergo further nitration to form dinitrobenzene



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.
