

22315

21222

3 Hours / 70 Marks

Seat No.

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15 minutes extra for each hour

- 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.

Marks

1. Attempt any FIVE of the following :

10

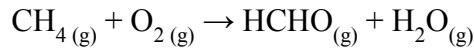
- (a) Define work and state its SI unit.
- (b) Define atomic weight and molecular weight.
- (c) List out any four unit operation used in chemical industry.
- (d) Write the stoichiometric coefficients of HCl, O₂, Cl₂ and H₂O for the given reaction $4\text{HCl} + \text{O}_2 \rightarrow 2\text{Cl}_2 + 2\text{H}_2\text{O}$
- (e) Define calorific values of fuel.
- (f) State Hess's law of constant heat summation.
- (g) Convert 30 KPa pressure into (i) bar (ii) mm of Hg

2. Attempt any THREE of the following :

12

- (a) 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 bottom product per 1000 kg of feed per hour. Also calculate the % recovery of benzene.

- (b) Write material balance equation for evaporator with block diagram.
- (c) In the manufacture of sulphur trioxide, feed to a reactor consists of 50 kmol SO₂ and 150 kmol air. Calculate the % excess air is used.
- (d) Calculate the enthalpy change between reactant and products if both are at 298.15 K and if 10 mol of formaldehyde is produced according to the following reaction :



Data :

Component	ΔH_C° , kJ/mol
CH _{4(g)}	- 890.65
HCHO _(g)	-563.46

3. Attempt any THREE of the following :

12

- (a) State Boyle's law and Charle's law with their mathematical statement.
- (b) It is desired to have a mixed acid containing 40% HNO₃, 43% H₂SO₄ and 17% H₂O by weight. Sulphuric acid of 98% by weight is readily available. Calculate (a) the strength of nitric acid and (b) weight ratio of sulphuric acid to nitric acid.
- (c) Oxidation of ethylene to produce ethylene oxide is given by the reaction :

$\text{C}_2\text{H}_4 + \frac{1}{2} \text{O}_2 \rightarrow \text{C}_2\text{H}_4\text{O}$. If air is used 20% in excess of that theoretically required, calculate the quantity of air supplied based on 100 k mol of ethylene fed to the reactor.

- (d) Pure ethylene is heated from 303 K (30 °C) to 523 K (250 °C) at atmospheric pressure. Calculate the heat added per kmol ethylene using the heat capacity data given below :

$$C_p^\circ = 4.1261 + 155.0213 \times 10^{-3} T - 81.5455 \times 10^{-6} T^2 + 16.9755 \times 10^{-9} T^3.$$

4. Attempt any THREE of the following :**12**

- (a) In a multiple effect evaporator system, the second effect is maintained under vacuum of 475 torr (mm Hg). Find the absolute pressure in KPa.
- (b) Air contains 21% O₂ and 79% N₂ by volume. Calculate average molecular weight of air.
- (c) Write material balance equation for distillation with block diagram.
- (d) Ammonia is produced by the following equation $N_2 + 3H_2 \rightarrow 2NH_3$

Calculate : (a) The molal flow rate of hydrogen corresponding to nitrogen feed rate of 25 kmol/hr if they are fed in the stoichiometric proportion.

(b) The kg of ammonia produced per hour if % conversion is 25 and nitrogen feed rate is 25 kmol/hr.

- (e) A sample of dry flue gas has the following composition by volume :

CO₂ = 13.4%, N₂ = 80.5%, O₂ = 6.1%. Find the % excess air supplied assuming that the fuel contained no nitrogen, the nitrogen and oxygen in flue gas must have come from air.

5. Attempt any TWO of the following :**12**

- (a) A gas mixture contains 0.274 kmol of HCl, 0.337 kmol of N₂ and 0.089 kmol of O₂. Calculate (a) Average molecular weight of gas (b) volume occupied by this mixture at 405.3 KPa and 303 K (30 °C).
- (b) 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) the kg of product obtained.

P.T.O.

- (c) 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.

6. Attempt any TWO of the following :

12

- (a) In the production of sulphur trioxide, 100 kmol of SO_2 and 100 kmol of O_2 are fed to the reactor. If the percent conversion of SO_2 is 80, calculate the composition of the product stream on mole basis.
- (b) Gas containing 25% CO , 5% CO_2 , 2% O_2 and rest N_2 by volume is burnt with 25% excess air. If the combustion is 90% complete, calculate the composition by volume of flue gases.
- (c) Calculate the standard heat of reaction at 298.15 K when gaseous ammonia is dissolved in water to form 2% by weight ammonia solution.

Data :

Component	ΔH_F° , kJ/mol
$NH_3(g)$	-49.94
$NH_4OH(l)$	-361.20
$H_2O(l)$	-285.83
