22315

21222

3 Hours / 70 Marks Seat No. | | | | | | | | |

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, O_2, Cl_2 and H_2O for the given reaction $4HCl + O_2 \rightarrow 2Cl_2 + 2H_2O$

(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 SO_2 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 :

$CH_{4\,(g)} + O_{2\,(g)} \rightarrow HCHO_{(g)} + H_2O_{(g)}$

Data :

Component	$\Delta H_C°$, 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% HNO_3, 43% H_2SO_4 and 17% H_2O 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 :

$C_2H_4 + \frac{1}{2} O_2 \rightarrow C_2H_4O$. 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 :

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

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% O_2 and 79% N_2 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 :

CO_2 = 13.4%, N_2 = 80.5%, O_2 = 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 HC*l* 0.337 kmol of N_2 and 0.089 kmol of O_2. 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.

(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	$\Delta H_F°$, kJ/mol
$NH_{3\,(g)}$	–49.94
$NH_4OH_{(l)}$	–361.20
$H_2O_{(l)}$	–285.83