22315

12425

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

Instructions : (1) All Questions are *compulsory.*

(2) Illustrate your answers with neat sketches wherever necessary.

(3) Figures to the right indicate full marks.

(4) Assume suitable data, if necessary.

(5) Use of Non-programmable Electronic Pocket Calculator is permissible.

Marks

1. Attempt any FIVE of the following : **10**

(a) Define pressure and write its SI unit.

(b) State Charle's law with its mathematical expression.

(c) List out different unit operations used in the chemical industry (any four).

(d) Write the stoichiometric ratio of SO_2 to O_2 for the given reaction

$$SO_2 + \frac{1}{2} O_2 \longrightarrow SO_3$$

(e) Explain the term net calorific value.

(f) State the law of conservation of energy.

(g) Convert 50 lit/sec to m^3/hr.

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

(a) 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

(b) Describe recycle and bypass operation with neat diagram.

(c) Calculate the following for the reaction :

$C_2H_4 + 2Cl_2 \longrightarrow C_2HCl_3 + H_2 + HCl$

(i) The stoichiometric ratio of Cl_2 to C_2H_4.

(ii) If 4 Kmol Cl_2 are fed per Kmol C_2H_4, find the percent excess Cl_2.

(iii) The amount of HCl produced from 50 kg of C_2H_4 assuming reaction goes to completion.

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

Cp_m° for NH_3 between 311 K and 298 K = 35.86 kJ/Kmol · K

Cp_m° for NH_3 between 422 K and 298 K = 37.70 kJ/Kmol · K

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

(a) Equal masses of CO and N_2 are mixed together in a container at 300 K. The total pressure was found to be 405.3 KPa. Find the partial pressure of CO gas.

(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 :

(i) The kg. of water removed from wet solid

(ii) The kg. of product obtained

(c) Methane oxidation reactions are

$CH_4 + O_2 \longrightarrow HCHO + H_2O$

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

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

(d) Calculate the standard heat of reaction ΔH_R° of the following reaction :

$$CH_3Cl_{(g)} + KOH_{(s)} \longrightarrow CH_3OH_{(l)} + KCl_{(s)}$$

Data :

Component	ΔH_F° kJ/mol at 25 °C
$CH_3Cl_{(g)}$	–102.936
$KOH_{(s)}$	–239.2
$CH_3OH_{(l)}$	–424.764
$KCl_{(s)}$	–436.747

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

(a) In a multiple effect evaporator system the second effect is maintained under vacuum of 475 mm Hg. Find the absolute pressure in KPa.

(b) A sample of gas having volume of 1 m^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.

(c) Describe the distillation operation with the help of block diagram and overall material balance equation.

(d) Formaldehyde (HCHO) is produced from methanol in a catalytic reactor. The production rate of formaldehyde is 1000 kg/hr. if the conversion of methanol (CH_3OH) is 65%, calculate the required feed rate of methanol.

(e) The gross calorific value of gaseous n-propanol (C_3H_7OH) at 298 K is 2067.44 kJ/mol. Find its net calorific value, using the latent heat of water vapour at 298 K = 2442.5 kJ/kg.

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

(a) A mixture of CH_4 and C_2H_6 has density 1 kg/m^3 at 273 K and 101.325 KPa pressure. Calculate the mole % of CH_4 and C_2H_6 in the mixture.

(b) The waste acid from a nitrating process contains 30% H_2SO_4, 35% HNO_3 and 35% H_2O by weight. The acid is to be concentrated to contain 39% H_2SO_4, 42% HNO_3 by addition of concentrated sulphuric acid containing 98% H_2SO_4 and concentrated nitric acid containing 72% HNO_3 (by weight). Calculate the quantities of three acids to be mixed to get 1000 kg. of desired mixed acids.

(c) The burning of limestone $CaCO_3 \longrightarrow CaO + CO_2$ goes only 70% to completion in a certain kiln

(i) Determine the composition (wt.%) of the solid withdrawn from the kiln

(ii) Calculate the kilogram of CO_2 produced per kg. of limestone fed assuming that the limestone is pure.

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

(a) Sulphur dioxide is oxidized to sulfur trioxide. If the conversion is 70% and air is used in 80% excess over theoretical requirement, calculate :

(i) The Kmol air fed per Kmol Sulphur dioxide

(ii) The composition of gases leaving reactor.

(b) A coke is known to contain 90% carbon and 10% non-combustible ash (by weight)

(i) How many mol of oxygen are theoretically required to burn 100 kg. of coke completely ?

(ii) If 50% (mole) excess air is supplied.

Calculate the analysis of gases at the end of combustion.

(c) Calculate the heat of formation of n-phenol (C_6H_5OH) at 298.15 K from its elements 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 phenol crystals at 298.15 K = –3053.25 kJ/mol.
