22315

23242

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

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 pressure and state its unit in SI system.

(b) State Charles' law and give its mathematical expression.

(c) Give an overall material balance equation for an evaporator.

(d) $N_2 + H_2 \longrightarrow NH_3$

Which is the limiting component in the above reaction ? (reaction not balanced)

(e) Define Calorific Value.

(f) Define latent heat of formation.

(g) Write the units of force, work in SI system.

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

(a) A feed to a continuous fractionating column analyses by weight 28 percent benzene and 72 percent toluene. The analysis of the distillate shows 52 weight percent benzene and 5 weight percent 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 percent recovery of benzene.

(b) Describe Drying operation with the help of block diagram and overall material balance.

(c) Explain the terms :

(i) Conversion of reactant

(ii) Yield of product

(d) Prove that for an ideal gas

$C_p - C_v = R$

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

(a) Calculate the volume occupied by 20 kg of chlorine gas at a pressure of 100 kPa and 298 K.

(b) The groundnut seeds containing 45% oil and 45% solids are fed to an expeller, the cake coming out of expeller is found to contain 80% solids and 5% oil. Find the percentage recovery of oil.

(c) 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.

(d) State Hess's law of constant heat summation and give its application.

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

(a) In a multiple effect evaporator system, the second effect is maintained under a vacuum of 475 torr. Find the absolute pressure in kPa.

(b) Assuming air to contain 79% N_2 and 21% O_2 by volume, calculate the density of air at NTP.

(c) A single effect evaporator is fed with 10000 kg/h of weak liquor containing 15% caustic by weight and is concentrated to get thick liquor containing 40% by weight caustic (NaOH). Calculate :

(i) kg/h of water evaporated and

(ii) kg/h of thick liquor obtained

(d) A combustion reactor is fed with 50 kmol/h of butane and 2100 kmol/h of air. Calculate the % excess air used.

(e) Give classification of fuels with four examples of each class used in the chemical industry.

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

(a) 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.

(b) A waste acid from a nitrating process contains 23% HNO_3, 57% H_2SO_4 and 20% water by weight. This acid is to be concentrated to contain 27%, HNO_3, 60% H_2SO_4 by the addition of concentrated H_2SO_4 containing 93% H_2SO_4 and concentrated nitric acid containing 90% HNO_3.

Calculate the amounts in kg of waste and concentrated acids that must be combined to obtain 1000 kg of desired mixture.

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

$$2A + B \longrightarrow C$$

Find the composition of the product stream on mole basis.

P.T.O.

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

(a) Ethylene oxide is produced by oxidation of ethylene 100 kmol of ethylene are fed to a reactor and the product is found to contain 80 kmol ethylene oxide and 10 kmol CO_2. Calculate :

(i) the percent conversion of ethylene and

(ii) the percent yield of ethylene oxide

(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 heat needed to raise the temperature of 1 kmol of ammonia from 311 K (38 °C) to 422 K (149 °C) using the mean molal heat capacity. Data :

C°_{pm} for NH_3 between 311 K and 298 K = 35.8641 kJ/(kmol · K)

C°_{pm} for NH_3 between 422 K and 298 K = 37.7063 kJ/(kmol · K)