22315

24225

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 power and write its unit in SI.

(b) Write Van der Waal's equation and give meaning of terms involved in it.

(c) Draw a block diagram indicating overall and component balance for distillation process.

(d) Define percent conversion.

(e) Define gross calorific value.

(f) Define standard heat of combustion.

(g) Convert a volumetric flow rate of 6000 m^3/hr to liter/sec.

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

(a) Tray dryer is fed with 1000 kg of wet ortho-nitroaniline containing 10% water. The dried product contains 99.5% ortho-nitroaniline and rest water. Find the percentage of original water that is removed in the dryer.

(b) 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 (a) water evaporated per hour (b) flow rate of thick liquor.

(c) In the manufacture of acetic acid (CH_3COOH) by oxidation of acetaldehyde (CH_3CHO), 100 kmole of acetaldehyde is fed to a reactor per hour. The product leaving the reactor contains 14.81% acetaldehyde, 59.26% acetic acid and rest oxygen (on mole basis). Find the percentage conversion of acetaldehyde.

(d) State and explain the Hess's law of constant heat summation.

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

(a) A gas contained in a closed vessel at a pressure of 121.59 kPa absolute and 299 K heated to a temperature of 373 K. Find the pressure to which a closed vessel should be designed.

(b) A mixture of phenol and water forms two separate liquid phases, one rich in phenol and other rich in water, composition of layer is 70% and 9% (by wt) phenol respectively. If 500 kg of phenol and 700 kg of water are mixed and layers allowed to separate, what will be the weights of two layers ?

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

(d) Calculate the standard heat of reaction at 298 K of the following reaction :

Data :

Component	Δ Hf kJ/mol at 298 K
$Na_2CO_{3(s)}$	– 1130.68
$Fe_2O_{3(s)}$	– 817.3
$Na_2O \cdot Fe_2O_{3(s)}$	– 1412.2
CO_2	– 393.51

$$Na_2CO_{3(s)} + Fe_2O_{3(s)} \longrightarrow Na_2O \cdot Fe_2O_{3(s)} + CO_{2(s)}$$

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

(a) Calculate volume occupied by a 100 kg of gas containing 90% benzene (C_6H_6) and 10% Nitrogen (N_2) at a temperature of 423 K and a pressure of 151.988 kPa [At. wt C = 12 H = 1 N = 14].

(b) In multiple effect evaporator system, the second effect is maintained under vacuum of 575 mm Hg. Find the absolute pressure in kPa.

(c) Soyabean seeds are extracted with hexane in batch extractors. The flaked seeds are found to contain 18.6% oil, 69% solid 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.

(d) A combustion reactor is fed with 50 kmol/hr of butane and 2000 kmole/hr of air. Calculate the % excess air used.

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

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

(a) A gas mixture has the following composition by volume : SO_2 = 15%, O_2 = 10%, N_2 = 75%. Find (a) The density of gas mixture at a temperature of 373 K and 150 kPa and (b) Composition of gas mixture by weight.

[At. wt. S = 32]

(b) The spent acid from a nitrating process contains 33% H_2SO_4, 36% HNO_3, 31% H_2O by weight. This acid is to be strengthened by addition of concentrated sulfuric acid containing 95% H_2SO_4 and concentrated nitric acid containing 78% HNO_3. The strengthened mixed acid is to contain 40% H_2SO_4 and 43% HNO_3. Calculate the quantities of spent acid and concentrated acids that should be mixed to yield 1500 kg of desired mixed acid.

(c) Calculate the heat of formation of phenol crystals at 298.15 K from its elements using the following 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

Standard heat of combustion of phenol crystals at 298.15 K = – 3053.25 kJ/mol.

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

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

(a) The kmole air fed per kmole sulfur dioxide

(b) The composition of gases leaving reactor (on volume basis)

(b) Crude oil is analysed to contain 87% carbon, 12.5% hydrogen and 0.5% sulfur (by weight). Calculate the net calorific value of the crude oil at 298 K.

Data : Gross calorific value of crude oil at 298 K= 2442.5 kJ/kg.

Latent heat of water vapour = 2260 kJ/kg

(c) A feed containing 60 mole % A, 30 mole % B and 10 mole % inerts enters a reactor. The product stream leaving the reactor is found to contain 2 mole % A. Reaction taking place is

$2A + B \longrightarrow C$

Find the percentage of original A getting converted to C.

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