

22315

24225

3 Hours / 70 Marks

Seat No.

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- 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<sup>3</sup>/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 ( $\text{CH}_3\text{COOH}$ ) by oxidation of acetaldehyde ( $\text{CH}_3\text{CHO}$ ), 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.

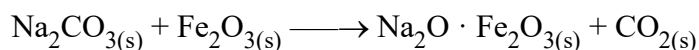
**3. Attempt any THREE of the following :**

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 ( $\text{HCHO}$ ) is produced from methanol ( $\text{CH}_3\text{OH}$ ) 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	$\Delta H_f$ kJ/mol at 298 K
$\text{Na}_2\text{CO}_{3(s)}$	- 1130.68
$\text{Fe}_2\text{O}_{3(s)}$	- 817.3
$\text{Na}_2\text{O} \cdot \text{Fe}_2\text{O}_{3(s)}$	- 1412.2
$\text{CO}_2$	- 393.51



**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  $\text{CO}_{2(g)} = -393.51 \text{ kJ/mol}$

Standard heat of formation of  $\text{H}_2\text{O}_{(l)} = -285.83 \text{ kJ/mol}$

Standard heat of combustion of phenol crystals at 298.15 K =  $-3053.25 \text{ kJ/mol}$ .

**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

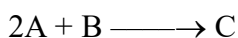
(b) The composition of gases leaving reactor (on volume basis)

- (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 =  $2442.5 \text{ kJ/kg}$ .

Latent heat of water vapour =  $2260 \text{ kJ/kg}$

- (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



Find the percentage of original A getting converted to C.

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