

17315

21819

3 Hours / 100 Marks

Seat No.

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- 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) Use of Non-programmable Electronic Pocket Calculator is permissible.
  - (6) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

**Marks**

1. (A) Attempt any FOUR of the following :

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- (i) State Henry's law & Raoult's law.
- (ii) Define limiting reactant & excess reactant.
- (iii) Define standard heat of formation and standard heat of combustion.
- (iv) What is Recycling operation ? State one purpose of recycling operation.
- (v) Define partial pressure and pure component volume.
- (vi) The carbon monoxide is reacted with hydrogen to produce methanol.

**(B) Attempt any TWO of the following :**

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- (i) A mixture of phenol & water forms two separate liquid phases, one rich in phenol and other rich in water, composition of layers is 70% and 9% (by weight) phenol resp. If 500 kg of phenol & 700 kg of water are mixed and layers allowed to separate, what will be the weights of two layers ?
- (ii) Calculate the numbers of cubic metres of acetylene gas at a temperature of 313 °k and pressure of 100 kPa that may be produced from 5 kg of calcium carbide.
- (iii)  $\text{SO}_2$  is oxidised to  $\text{SO}_3$ . If the conversion is 70% and air is used in 80% excess than theoretical requirement.

Calculate : (a) kmol of air fed per kmol of  $\text{SO}_2$ , (b) Composition of gases leaving the reactor on mole basis.

**2. Attempt any FOUR :**

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- (i) A combustion reactor is fed with 50 kmol/h of butane and 2100 kmol/h of air. Calculate the % excess of air used.
- (ii) State and explain Hess's law of constant heat summation.

- (iii) It is desired to make up 1000 kg of solution containing 35% by weight of substance 'A'.

Two solutions are available, one containing 10% by weight A and other containing 50% by weight A.

How many kilograms of each solution will be required ?

- (iv) Tray dryer is fed with 1000 kg of wet orthonitro aniline (ONA) containing 10% water. The dried product contains 99.5% ONA and rest water.

Calculate the percentage of original water removed in dryer.

- (v) A mixture of  $\text{CH}_4$  and  $\text{C}_2\text{H}_6$  has the average molecular weight of 22.4. Find the mol % of  $\text{CH}_4$  &  $\text{C}_2\text{H}_6$  in mixture.

- (vi) A feed containing A, B and inert enters a reactor. The reaction taking place is  $2\text{A} + \text{B} \rightarrow \text{C}$ . The product leaving the reactor contains 23.08% A, 11.54% B, 46.15% C and 19.23% inert (by mole). Find the analysis of feed on mole basis.

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

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- (i) In the manufacture of chlorine, feed containing hydrochloric acid gas and air are fed to an oxidiser. The product gases leaving the oxidiser are found to contain 13.2% HCl, 6.3%  $\text{O}_2$ , 42.9%  $\text{N}_2$ , 30%  $\text{Cl}_2$  and 7.6%  $\text{H}_2\text{O}$  (by weight). Calculate : (a) The percent excess air used. (b) Composition of gas mixture entering the oxidiser, by weight.

**P.T.O.**

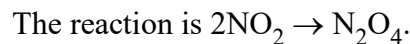
- (ii) A stream flowing at a rate of 15000 mol/h containing 25 mol%  $N_2$  & 75 mole %  $H_2$  is to be heated from 298 °K to 473 °K.

Calculate the heat that must be transferred, using  $C_p^\circ$  data given below :

$$C_p^\circ = a + bT + cT^2 + dT^3, \text{ kJ/k mol.K.}$$

Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
$N_2$	29.5909	-5.41	13.1829	-4.968
$H_2$	28.6105	1.0194	-0.1476	0.769

- (iii) In one case, 26.6 lit of  $NO_2$  at 80 kPa & 298 °K is allowed to stand until the equilibrium is reached. At equilibrium, the pressure is found to be 66.662 kPa. Calculate the partial pressure of  $N_2O_4$  in the final mixture.



**4. Attempt any TWO of the following :**

**16**

- (i) The waste acid from a nitrating process contains 30%  $H_2SO_4$ , 35%  $HNO_3$  & 35%  $H_2O$  by weight. The acid is to be concentrated to contain 39%  $H_2SO_4$  & 42%  $HNO_3$  by adding conc.  $H_2SO_4$  acid containing 98%  $H_2SO_4$  and conc.  $HNO_3$  acid containing 72%  $HNO_3$  (by weight).

Calculate the quantities of acids to be mixed to get 1000 kg of desired mixed acid.

- (ii) A feed containing 60 mole % A, 30 mole % B & 10 mole % inerts enters a reactor. The product stream leaving the reactor is found to contain 2 mole % A. The reaction taking place is  $2A + B \rightarrow C$ .

Find the percentage of original 'A' getting converted to 'C'.

- (iii) 10,000 kg/hr of feed containing 20% methanol is continuously fed to a distillation column. Distillate is found to contain 98% methanol and waste solution (bottom product) contains 1% methanol. All percentages are by weight. Calculate : (a) mass flow rates of top & bottom product. (b) Percent loss of methanol.

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

**16**

- (i) Centrifuge is fed with a slurry containing 25% solid by weight and wet solid obtained after drying is found to contain 8% moisture by weight and filtrate is found to contain 200 PPM solids.

If centrifuge machine produces 100 kg/h desired wet product and quantity of slurry to be handled is 5000 kg per batch. Calculate : (i) time required for filtration, (ii) Loss of solids in filtrate per batch.

- (ii) Pure sulphur is burnt in a sulphur burner with dry air. Oxygen is used 20% excess for complete combustion of sulphur to  $SO_3$ . The efficiency of burner is such that only 30% sulphur is converted to  $SO_3$  and remaining to  $SO_2$ . Calculate (a) Composition of gases leaving the burner, (b) The weight of gas per kg of sulphur burnt.

**P.T.O.**

- (iii) Calculate the heat that must be removed in cooling 32 kg of oxygen from 488 °K to 313 °K. Using  $C_p^\circ$  data.

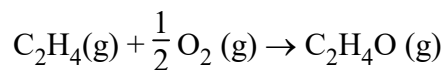
$$C_p^\circ = a + bT + cT^2 + dT^3 \text{ kJ}/(\text{kmol} \cdot ^\circ\text{K})$$

Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
O <sub>2</sub>	26.0257	11.7551	-2.3426	-0.5623

6. Attempt any FOUR of the following :

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- (i) Calculate the change in enthalpy between reactants and products if both are at 298 K & if 5 mol of C<sub>2</sub>H<sub>4</sub>O is produced as per following reaction



Data :

Component	$\Delta H_f^\circ$ , kJ/mol at 298 K
C <sub>2</sub> H <sub>4</sub> (g)	52.50
C <sub>2</sub> H <sub>4</sub> O(g)	-52.63

- (ii) A natural gas has the following composition by volume. CH<sub>4</sub> – 82%, C<sub>2</sub>H<sub>6</sub> – 12% & N<sub>2</sub> – 6%. Calculate the density of gas at 288 k & 101.325 kPa.
- (iii) The NH<sub>3</sub> – air mixture containing 0.2 kg NH<sub>3</sub> per kg air, enters into absorption system where NH<sub>3</sub> is absorbed in water. The gases leaving the system is found to contain 0.004 kg NH<sub>3</sub> per kg of air. Calculate the percentage recovery of NH<sub>3</sub>.

- (iv) Ethylene oxide is produced by oxidation of ethylene. 100 kmol of ethylene is fed to reactor and product contains 80 kmol of ethylene oxide & 10 kmol of  $\text{CO}_2$ . Calculate % conversion of ethylene & % yield of ethylene oxide.
- (v) 100 kmol of ethanol are charged to dehydrogenation reactor to produce acetaldehyde. The product stream contains 45 kmol acetaldehyde. Calculate percent conversion of ethanol.
- (vi) A wet lumber containing 5%  $\text{H}_2\text{O}$ , is dried to 1% water in a hot air dryer. Air containing 0.5 wt% water is fed to the dryer. The moist air leaving the dryer contains 2% water. Calculate the air required to dry 2000 kg/h of wet lumber.
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