*Name : .....*

*Roll No. : .....*

*Invigilator's Signature : .....*

**CS/B.TECH(BT-OLD)/SEM-3/BT-304/2011-12**

# 2011
# INDUSTRIAL STOICHIOMETRY

*Time Allotted :* 3 Hours *Full Marks :* 70

*The figures in the margin indicate full marks.*

*Candidates are required to give their answers in their own words as far as practicable.*

*Log-Log graph paper will be supplies by the Institute on demand.*

## GROUP – A

## ( Multiple Choice Type Questions )

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) Dimension of force is

   a) $ML^{-1} T^{-1}$ b) $ML^{-3}$

   c) $L^2T^{-1}$ d) $MLT^{-2}$.

   ii) Number of gm moles of solute dissolved in one litre of a solution is called its

   a) equivalent weight b) molarity

   c) molality d) normality.

iii) ..... equation gives the effect of temperature on heat of reaction.

a) Kirchhoff's b) Maxwell's

c) Antonie d) Kistyakowsky.

iv) In a chemical process, the recycle stream is purged for

a) increasing the yield b) enriching the product

c) limiting the inerts d) none of these.

v) $C_p/C_v$ for monatomic gases is

a) 1.44 b) 1.66

c) 1.99 d) 1.

vi) Volume occupied by one gm mole of a gas at S.T.P. is

a) 22.4 litres b) 22400 litres

c) 22.4 c.c d) 359 litres.

vii) Volume per cent for gases is equal to

a) weight per cent

b) mole per cent

c) weight per cent only for ideal gas

d) mole per cent only for ideal gas.

viii) Significance of Nusselt No. is

a) Inertia force/viscous force

b) Pressure force / gravity force

c) Molecular diffusivity of momentum / molecular diffusivity of heat

d) Wall heat transfer rate / heat transfer by conduction.

ix) 1 bar is almost equal to ..... atmosphere.

a) 1 b) 100

c) 1000 d) 10.

x) Bucking $P_i$ method is used to determine the

a) dimensional analysis b) chemical analysis

c) physical analysis d) none of these.

xi) Dimension of density is

a) $ML^3$ b) $ML^{-3}$

c) $M^3L$ d) none of these.

xii) Crystallization is a

a) unit operation b) unit process

c) unit separation d) none of these.

## GROUP – B

### ( Short Answer Type Questions )

Answer any *three* of the following. 3 × 5 = 15

2. The absolute humidity of air is 0.015 kg water vapour/kg dry air. Assuming the average molecular weight of air to be 29. Calculate the following :

   a) The mole per cent of water vapour in the air

   b) The molal absolute humidity which is same as the mole ratio of water vapour to dry air. 2 + 3

3. Write short notes on the following : 5 × 1

   a) Excess reactant

   b) Limiting reactant

   c) Selectivity

   d) Tie element

   e) Degrees of freedom.

4. Assuming air to behave as an ideal gas, calculate the molar volume of air at 350 K and 1 bar. 5

5. Draw and explain pressure-temperature ( $P - T$) diagram of a pure substance. 5

6. Calculate the standard heat of reaction of the following : 5

   $HCl\ (g) + NH_3\ (g) = NH_4Cl\ (s)$

   Standard heats of formation at 25°C are for

   | | |
   |---|---|
   | HCl (g) | – 22, 063 cal |
   | $NH_3$ (g) | – 11, 040 cal |
   | $NH_4$ Cl (s) | – 75, 380 cal |

## GROUP – C

**( Long Answer Type Questions )**

Answer any *three* of the following. 3 × 15 = 45

7. a) State Roult's law. 2

b) Write down the groups and significance of Sherwood No. & Reynolds No. 3

c) In the Le Blanc soda process the first step is carried out according to the following reaction :

$2NaCl + H_2SO_4 = NaCl + NaHSO_4 + HCl$

The acid contains 80.0% $H_2SO_4$. It is supplied in 5% excess of that theoretically required for the above reaction :

(i) Calculate the weight of acid supplied per 1000 lb of salt charged.

(ii) Assume that the reaction goes to completion, all the acid forming bi-sulphate, and that in the process 90% of the HCl formed and 25% of the water present and removed. Calculate the weights of HCl and water removed per 1000 lb of salt charged.

(iii) Assuming the condition in (ii), calculate the percentage composition of the remaining salt mixture, 10

8. For a pipeline of given length and diameter, the frictional pressure drop $\Delta P$ is dependent only on the velocity $u$ of water flowing through it. For turbulent flow, the relationship between the two is given by

$$\Delta P = ku^2$$

From the experimental data given below, find the value of $k$ :

| $u$,cm/s | 1 | 3 | 5 | 7 | 9 | 12 | 15 |
|---|---|---|---|---|---|---|---|
| $\Delta P$ kPa | 2.55 | 17.16 | 44.13 | 80.42 | 122.59 | 205.95 | 318.73 |

Use log-log graph paper only. 15

9. a) Define adiabatic reaction temperature and write down the Clausisu-Clayron equation. 3

b) A distillation column separates 10,000 kg/hr of a 50% benzene-50% toluene mixture. The product $D$ recovered from the condenser at the top of the column contains 95% benzene, and the bottom $W$ from the column contains 96% toluene. The vapour stream $V$ entering the condenser from the top of the column is 8000 kg/hr. A portion of the product from the condenser is returned to the column as reflux, and rest is withdrawn for use elsewhere. Assume that the composition of the stream at the top of the column ($V$), the product withdrawn ($D$), and the reflux ($R$) are identical because the $V$ stream is condensed completely. Find the ratio of the amount refluxed $R$ to the product withdrawn $D$. 12

10. A tank holds 10,000 kg of a saturated solution of $Na_2CO_3$ at 30°C. You want to crystallize from this solution 3000 kg of $Na_2CO_3$. 10 $H_2O$ without any accompanying water. Determine at what temperature the solution must be cooled.

| Temp. (°C) | Solubility (g $Na_2CO_3$/100g $H_2O$) |
|---|---|
| 0 | 7 |
| 10 | 12.5 |
| 20 | 21.5 |
| 30 | 38.8 |

15