



Name : .....

Roll No. : .....

Invigilator's Signature : .....

**CS/B.Tech(CHE-OLD)/SEM-3/CHE-301/2012-13**

**2012**

**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.*

**GROUP – A**

**( Multiple Choice Type Questions )**

1. Choose the correct alternatives for any *ten* of the following : 10 × 1 = 10

i) The equation,  $y = ab^{cx}$ , will produce a straight line in

- a) linear graph paper
- b) log-log graph paper
- c) semi-log paper
- d) triangular graph paper.

ii) An ideal solution is one which obeys

- a) Raoult's Law
- b) Amagat's Law
- c) Charles' Law
- d) Dalton's Law.

iii) 1° Brix is equivalent to a sugar solution

- a) 10% sugar
- b) 1% sugar
- c) 0.1% sugar
- d) 0.01% sugar.

3007(O)

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- iv) Air has 21% O<sub>2</sub> and 79% N<sub>2</sub> by volume respectively.  
What is its average molecular weight ?

a) 29	b) 28.84
c) 29.3	d) 29.

v) One newton is equal to

a) 10 <sup>3</sup> dynes	b) 10 dynes
c) 10 <sup>2</sup> dynes	d) 10 <sup>5</sup> dynes.

vi) For ideal gas C<sub>p</sub> - C<sub>v</sub> is equal to

a) zero	b) R
c) 2R	d) $\frac{3}{2}$ R.

vii) 1 kg/cm<sup>2</sup> is equal to

a) 5 m water	b) 1 m water
c) 760 mm water	d) 10 m water.

viii) The vapour pressure of water at 100°C is

a) 100 N/m
b) 76 cms of Hg
c) 13.56 cms of Hg
d) 760 mm of water column.

ix) The input and output of a furnace have got the following composition by volume.

*Input :*

*Output :*

Fuel gas + 100% excess Air

( Flue gas )

CRt 12%

CO<sub>2</sub> 4.71%CS<sub>2</sub> 28%

H<sub>2</sub> O 3.05%

CO<sub>2</sub> 11%

O<sub>2</sub> 10.4%

H<sub>2</sub> 9%

N<sub>2</sub> 81.84%

N<sub>2</sub> 40%

on SO<sub>2</sub> free Basis

In this system the tie component is

- a) SO<sub>2</sub>  
c) N<sub>2</sub>
- b) H<sub>2</sub>O  
d) CO<sub>2</sub>

CS/B.Tech(CHE-OLD)/SEM-3/CHE-301/2012-13



- x) The unit of  $g_c$  (Newtonian gravitational constant ) in MKS unit is
- a)  $m/s^2$  b)  $kg/m$
- c)  $kgm/kgf. N. s^2$  d)  $kg.m/N. s^2 .$
- xi) 'Cox' chart which is useful in the design of a distillation column (particularly suitable for petroleum hydrocarbon) is a plot of the
- a) temperature vs log ( vapour pressure )
- b) vapour pressure vs log ( temperature )
- c) log ( temperature ) vs log ( vapour pressure )
- d) log ( vapour pressure ) vs log ( temperature ).

**GROUP – B**

**( Short Answer Type Questions )**

Answer any *three* of the following.  $3 \times 5 = 15$

2. Define and explain units and dimensions with examples. Give examples of 5 ( five ) derived quantities in SI units with their symbolic abbreviations and dimensions.

The volumetric flow rate of kerosene in an 80 mm nominal diameter pipe is 75 imperial gallons / minute. Taking the density of kerosene as  $0.8 \text{ kg/dm}^3$ , find the mass flow in kg/s.

3. Define and explain  $DB$ ,  $WB$  and  $DP$  and also state when  $DB = WB = DP$ . What do you mean by psychrometry ? What do you mean by humid heat and humid volume ?

The dry bulb temperature and dew point of ambient air were found to be 302 K ( 29° C ) and 291 K ( 18°C ) respectively. Barometer reads 100 kPa ( 750 torr ).

CS/B.Tech(CHE-OLD)/SEM-3/CHE-301/2012-13



Calculate :

- a) the absolute molal humidity
- b) the absolute humidity
- c) % RH
- d) % saturation
- e) humid heat & humid volume.

Given vapour pressure of water at 291 K = 2.0624 kPa,  
Vapour at saturation i.e. at 302 K = 4.004 kPa.

4. Calculate the specific volume of superheated steam at 10 MPa and 623 K ( 350° C ) using
  - a) the ideal gas law
  - b) the van der Waals' equation.

If the actual specific volume of steam at the above conditions is 0.022442 m<sup>3</sup>/kg, find the percentage error in the above cases.

5. What do mean by adiabatic flame temperature ? Calculate the heat that must be added to 3 k.mol air to heat it from 298 K ( 25° C ) to 473 K ( 100° C ) using mean molal heat capacity data for air as mentioned below :

$C_{pm}^{\circ}$  (between 473 K and 298 K) for air = 29.3955 kJ/k.mol.K

6. State and explain Hess's Law of heat summation with suitable example.

3007(O)

4

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**GROUP – C****( Long Answer Type Questions )**Answer any *three* of the following.  $3 \times 15 = 45$ 

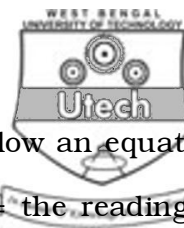
7. Describe the Buckingham method for forming dimensionless groups.

The frictional pressure drop  $\Delta p$  for the flow of a fluid through a long, straight, round pipe depends upon the length  $l$ , diameter  $d$  and average height of the wall roughness  $e$  of the pipe. The average fluid velocity is  $u$ , the density and viscosity of the fluid being  $\rho$  and  $\mu$  respectively. Use the Buckingham method to make a dimensional analysis of the system.

8. An orifice calibration gave the following readings :

Average velocity of water in pipe	Orifice manometer reading
Feet per second	millimeters of mercury,
3.42	30.3
4.25	58.0
5.25	75.5
5.88	93.5
7.02	137.5
7.30	148.0
10.05	261.0

CS/B.Tech(CHE-OLD)/SEM-3/CHE-301/2012-13



If the flow through an orifice is known to follow an equation of the type  $u = kR^n$  where  $u$  = the velocity,  $R$  = the reading of the manometer, determine the values of  $k$  and  $n$  for this particular orifice.

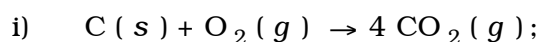
9. Describe the method of least squares for solving simultaneous equations.

Form normal equations and hence find the most plausible values of  $x$  and  $y$  from the following equations :

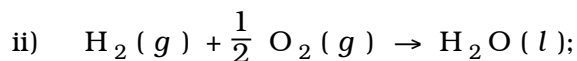
$$x + y = 3.01, 2x - y = 0.03, x + 3y = 7.03, 3x + y = 4.97.$$

10. a) Calculate the standard heat of formation of chloroform [  $\text{CHCl}_3 (g)$  ] from its elements using Hess's law.

*Data :*



$$\Delta H = - 94051 \text{ cal/gm mole}$$

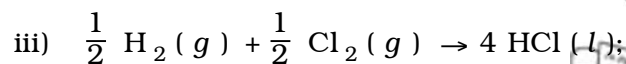


$$\Delta H = - 68317 \text{ cal/gm mole}$$

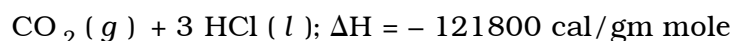
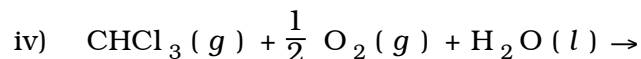
3007(O)

6

CS/B.Tech(CHE-OLD)/SEM-3/CHE-301/2012-13



$$\Delta H = -40020 \text{ cal/gm mole}$$



- b) In a reaction mixture carbon and oxygen are present in the mole ratio of 4 : 3. The desired reaction is  $\text{C} + \text{O}_2 = \text{CO}_2$ . With one atom of carbon and 0.75 mole of oxygen 0.5 mole  $\text{CO}_2$  is produced.

Identify the limiting reactant, the excess reactant, the percentage excess and the degree of completion of reaction.

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