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 : $10 \times 1 = 10$

   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.

iv) Air has 21% O_2 and 79% N_2 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) 10^3 dynes b) 10 dynes

c) 10^2 dynes d) 10^5 dynes.

vi) For ideal gas $C_p - C_v$ is equal to

a) zero b) R

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

vii) 1 kg/cm ^{2} 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_2 4.71%
CS_2 28%	H_2O 3.05%
CO_2 11%	O_2 10.4%
H_2 9%	N_2 81.84%
N_2 40%	on SO_2 free Basis

In this system the tie component is

a) SO_2 b) H_2O

c) N_2 d) CO_2

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 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).

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^3 /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} (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.

GROUP – C

(Long Answer Type Questions)

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

7. Describe the Buckingham method for forming dimensionless groups.

   The frictional pressure drop Δp 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 ρ and μ 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 Feet per second	Orifice manometer reading 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

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 [$CHCl_3$ (g)] from its elements using Hess's law.

Data :

i) $C(s) + O_2(g) \rightarrow 4\,CO_2(g)$;

$\Delta H = -94051$ cal/gm mole

ii) $H_2(g) + \frac{1}{2}\,O_2(g) \rightarrow H_2O(l)$;

$\Delta H = -68317$ cal/gm mole

iii) $\frac{1}{2} H_2(g) + \frac{1}{2} Cl_2(g) \rightarrow 4\ HCl(l)$;

$\Delta H = -40020$ cal/gm mole

iv) $CHCl_3(g) + \frac{1}{2} O_2(g) + H_2O(l) \rightarrow$

$CO_2(g) + 3\ HCl(l)$; $\Delta H = -121800$ cal/gm mole

b) In a reaction mixture carbon and oxygen are present in the mole ratio of 4 : 3. The desired reaction is $C + O_2 = CO_2$. With one atom of carbon and 0.75 mole of oxygen 0.5 mole CO_2 is produced.

Identify the limiting reactant, the excess reactant, the percentage excess and the degree of completion of reaction. 7 + 8