Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/B.Tech(BT)/SEM-3/BT-304/2010-11

2010-11

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 the following : $10 \times 1 = 10$

   i) Degree of reduction of ethanol is

      a) 6   b) 12

      c) 11   d) 2.

   ii) Specific heat capacity of water is

      a) 4·184 kJ/g°C   b) 1 cal/kg°C

      c) 4·184 kJ/kg°C   d) 1 kcal/g°C.

   iii) An ideal liquid solution follows

      a) Charles law

      b) equation of state

      c) Raoults law and Henry's law

      d) none of these.

iv) The temperature at which the first drop of vapour is formed is

a) bubble point b) dew point

c) boiling point d) melting point.

v) Heat of formation of carbon is

a) 0 kJ/mol b) – 393 kJ/mol

c) – 241·82 kJ/mol d) none of these.

vi) Volume per cent of a gas in a mixture is equal to

a) pressure per cent

b) mole per cent

c) weight per cent

d) mole per cent only for ideal gas.

vii) Standard atmospheric pressure is equal to

a) 10 psia b) 1·033 kg/cm ^{2}

c) 760 mm Hg d) both (b) and (c).

viii) Dimension of viscosity is

a) $ML^{-1}T^{-1}$ b) $ML^{2}T^{-1}$

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

ix) Prandtl number is

a) $\mu Cp/K$ b) V^2/gD

c) hD/K d) μ/KCp.

x) In a biochemical process, the recycle stream is purged for

a) increasing the yield b) enriching the product

c) limiting the inerts d) heat conservation.

GROUP – B

(Short Answer Type Questions)

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

2. A natural gas has following composition by volume :

CO_2 - 0·8%, N_2 - 3·2% and CH_4 - 96%.

Calculate : (a) the composition in weight percentage (b) the average molecular weight.

3. Mass flow through a nozzle as a function of gas pressure and temperature is given by $m = 0{\cdot}0549\ (P/T^{0{\cdot}5})$, where m is in lb/min, P is in psi and T is in °R. Obtain an expression of mass flow rate in kg/sec with P in atmospheres and T in Kelvin. Given T°R = T°F + 460 ;

14·7 psi = 1 atm.

4. An heat exchanger for cooling a hot hydrocarbon liquid uses 10,000 kg/hr of cooling water, which enters the exchanger at 294 K. The hot oil at the rate of 5000 kg/hr enters at 423 K and leaves at 338 K and has an average heat capacity of 2·51 kJ/KgK. Calculate the outlet temperature of water.

5. Define or state the following :

   a) Heat capacity

   b) First law of thermodynamics

   c) Heat of formation

   d) Degree of reduction

   e) Ideal solution.

6. A continuous distillation column is used to regenerate solvent for use in a solvent extraction unit. The column treats 200 kmol/hr of a feed containing 10% (mol) ethyl alcohol and the rest is water. The overhead product is 89% (mol) alcohol and the bottom product is 0·3% (mol) alcohol. The overhead is sent to the extraction unit and the bottom is wasted. What is the daily requirement of make-up alcohol in the solvent extraction unit ?

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. Consider the convective mass transfer of a fluid flowing in by forced convection through a pipe. The fluid is flowing at a velocity v, through a pipe of diameter D and has the density ρ, viscosity μ and the diffusivity D_{AB}. Relate the mass transfer coefficient K_c to the variables D, ρ, μ, v and D_{AB} using the Buckingham pi theorem.

8. Pure CO_2 may be prepared by treating limestone with aqueous H_2SO_4. The limestone contains $CaCO_3$ and $MgCO_3$ and the remaining is insoluble matter. The acid is 12% H_2SO_4. The residue from the process has the following composition :

$CaSO_4$	8·56%
$MgSO_4$	5·23%
H_2SO_4	1·05%
Inert	0·53%
CO_2	0·12%
Water	84·51%

Calculate :

a) Composition of limestone used

b) % excess acid used.

$CaCO_3 + H_2SO_4 = CaSO_4 + CO_2 + H_2O$

$MgCO_3 + H_2SO_4 = MgSO_4 + CO_2 + H_2O$. 8 + 7

9. Wet solid is fed to a drier to reduce the moisture content from 80% to 15%. The product leaving the drier again passed through an oven and further moisture is reduced to 2%. If the drier can handle 1000 kg of wet solid per day, Calculate :

   a) The weight of products leaving the drier and oven per day,

   b) The percentage of the original water that is removed in the drier and oven. 8 + 7

10. Flue gases leaving the stack of a boiler at 533 K have the following molar composition :

    CO_2 = 11·31%, H_2O = 13·04%, O_2 = 2·17% and N_2 = 73·48%. Calculate the heat loss in kmol of gas mixture above 298 K. Also calculate the average heat capacity of dry flue gas.

    C_p in kJ/kmolK is given in the following table,

    $C_p = a + bT + CT^2$

	a	b ∞ 10^3	C ∞ 10^6
CO_2	21·3655	64·284	– 41·0506
H_2O	18·56	33·23	– 52·16
O_2	26·0257	11·7551	– 2·3426
N_2	19·2494	52·1135	11·973

11. a) Carbon monoxide and water vapour react in stoichiometric amounts to form carbon dioxide and hydrogen. The feed enters at 25°C and the product leaves at 540°C with a carbon monoxide conversion of 75%. Determine the total amount of heat which must be added or removed in the reactor per 100 kg of hydrogen product. The following data may be used :

Component	***Heat of formation at* 25°C, kJ/kmol**	***Heat capacity* 25°C, kJ/(kmol K)**
CO	– 110600	30·35
H_2O	– 241980	36·00
CO_2	– 393770	45·64
H_2	0	29·30

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b) Define adiabatic flame temperature. 3