



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) $4.184 \text{ kJ/g}^\circ\text{C}$ | b) $1 \text{ cal/kg}^\circ\text{C}$ |
| c) $4.184 \text{ kJ/kg}^\circ\text{C}$ | d) $1 \text{ kcal/g}^\circ\text{C}$. |

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/cm²
- c) 760 mm Hg d) both (b) and (c).

viii) Dimension of viscosity is

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



ix) Prandtl number is

- a) $\mu C_p / K$ b) V^2 / gD
 c) hD / K d) μ / KC_p .

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. $3 \times 5 = 15$

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 $m = 0.0549 (P/T^{0.5})$, 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 $T^{\circ}R = T^{\circ}F + 460$;

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 × 15 = 45

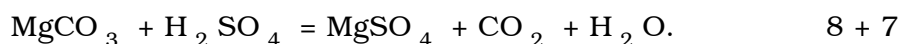
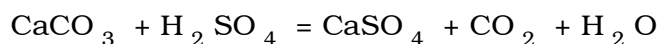
7. Consider the convective mass transfer of a fluid flowing in by forced convection through a pipe. The fluid is flowing at a velocity v , through a pipe of diameter D and has the density ρ , viscosity μ and the diffusivity D_{AB} . Relate the mass transfer coefficient K_c to the variables D , ρ , μ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





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 :

- The weight of products leaving the drier and oven per day,
- The percentage of the original water that is removed in the drier and oven.

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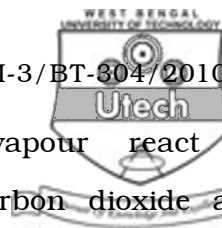
10. Flue gases leaving the stack of a boiler at 533 K have the following molar composition :

$\text{CO}_2 = 11.31\%$, $\text{H}_2\text{O} = 13.04\%$, $\text{O}_2 = 2.17\%$ and $\text{N}_2 = 73.48\%$. 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	$b \times 10^3$	$C \times 10^6$
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 ₂ O	- 241980	36.00
CO ₂	- 393770	45.64
H ₂	0	29.30

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- b) Define adiabatic flame temperature.

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