



Name :

Roll No. :

Invigilator's Signature :

CS/B.TECH/BT/FT/NEW/SEM-4/CH-401/2013
2013

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.*

Semi-log Graph paper will be supplied by the Institution.

GROUP - A

(Multiple Choice Type Questions)

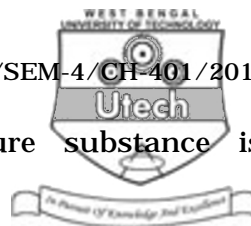
1. Choose the correct alternatives for any *ten* of the following :

$$10 \times 1 = 10$$

- i) To convert atmosphere (atm) to Pascal (Pa) conversion factor is
- a) 1.01325 b) 1.01325×10^5
c) 760 d) none of these.
- ii) Euler number is the ratio of
- a) Pressure force to inertial forces acting on the fluid element
b) Inertial forces to pressure force acting on the fluid element
c) Inertial forces to gravity force acting on the fluid element
d) Drag force to inertial forces acting on the fluid element.



- iii) A mole of compound contains
- a) one molecule of the substance
 - b) one atom of substance
 - c) 6.023×10^{23} molecules
 - d) 22.4×10^3 molecules.
- iv) Mole fraction of chlorine in the substance $\text{Ca}(\text{ClO})_2$ is
- a) 1
 - b) 0.5
 - c) 0.33
 - d) 0.22.
- v) 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.
- vi) The vapour pressure of a solution (made by dissolving a solute in a solvent) is of the pure solvent.
- a) less than
 - b) more than
 - c) equal to
 - d) either more or less, depending on the solvent.



- vii) The saturation temperature of pure substance is generally known as
- the critical temperature
 - the three phase temperature
 - the triple point
 - the boiling point.
- viii) In a dilute solution
- the solute obeys Henry's law
 - the solute and solvent obeys Henry's law
 - the solute obeys Raoult's law
 - the solvent obeys Henry's law.
- ix) For the estimation of heat capacity of a solid compound one can use
- Clapeyron equation
 - Gibbs equation
 - Kopp's rule
 - Watson equation.
- x) With increase in molecular weight, the vapour pressure of chemically similar liquid at any given temperature
- increases
 - decreases
 - remains unchanged
 - may increase or decrease.



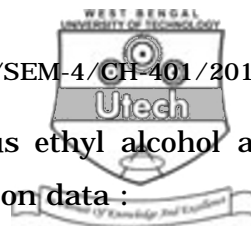
- xi) The heat supplied to a system under constant pressure is equal to
- the work done by the system
 - the change in internal energy
 - the change in enthalpy
 - the change in kinetic and potential energy.
- xii) Net heating value during combustion is
- the energy liberated when water is formed in the liquid state
 - the energy liberated when water is formed in the vapour state
 - the energy liberated when vapour is formed in the liquid state
 - none of these.

GROUP - B

(Short Answer Type Questions)

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

- For a centrifugal pump the pressure head H is a function of volumetric flow rate Q , the impeller diameter D , and the rotational speed of the impeller N . Relate the variables using Buckingham π theorem.
- A crystallizer is charged with 100 kg of a solution containing 25% $\text{Ba}(\text{NO}_3)_2$ in water. On cooling 10% of the original water present evaporates. Calculate the yield of crystal when the solution is cooled to 283 K, the solubility at 283 K is 7.0 kg $\text{Ba}(\text{NO}_3)_2$ / 100 kg total water.



4. Calculate the heat of formation of gaseous ethyl alcohol at 298 K using the following heat of combustion data :

Standard heat of combustion of hydrogen =

$$- 241.82 \text{ kJ/mol}$$

Standard heat of combustion of carbon = $- 393.51 \text{ kJ/mol}$

Standard heat of combustion of gaseous ethyl alcohol =

$$- 1278.04 \text{ kJ/mol.}$$

5. A wet stock of ammonium sulphate containing 20% water is sent to a drier. The material leaving the drier contains 2.44% moisture. Determine how many kg of water is removed per kg of wet material charged. Also find the per cent of original water in the feed that is removed by drying. (Consider the percentage composition of solids and liquids on wet basis) 3 + 2

6. Acetone is recovered from an acetone-air mixture containing 25% (volume) acetone by scrubbing with water. Assuming that air is insoluble in water, determine the per cent of acetone in the entering gas that is absorbed if the gas entering the scrubber analyzes 5% acetone.

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

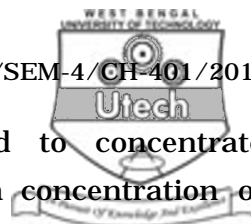
7. The concentration of drug (C_d) in blood during metabolism related with time as $C_d = ke^{-mt}$. From the given data calculate k and m using semi-log graph paper :

| Time (hr) | 1 | 2 | 3 | 4 | 5 | 6 |
|---------------------------|------|-------|------|-------|-------|------|
| Conc. of drug (mg/c.c.) | 2.25 | 1.143 | 0.63 | 0.396 | 0.279 | 0.09 |

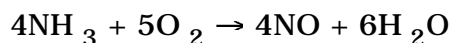
8. a) Acetone is recovered from an acetone-air mixture containing 25% (volume) acetone by scrubbing with water. Assuming that air is insoluble in water, determine the per cent of acetone in the entering gas that is absorbed if the gas leaving the scrubber analyzes 5% acetone.
- b) A 100 kg mixture of 27.8% of acetone (A) and 72.2% of chloroform (B) by mass is to batch extracted with a mixed solvent. The mixed solvent of an unknown composition is known to contain water (S1) and acetic acid (S2). The mixture of original mixture and the mixed solvent is shaken well, allowed to attain equilibrium and separated into two layers. The compositions of two layers are given below :

| Layer | Composition, mass % | | | |
|-------------|---------------------|------|------|------|
| | A | B | S1 | S2 |
| Upper layer | 7.5 | 3.5 | 57.4 | 31.6 |
| Lower layer | 20.3 | 67.3 | 2.8 | 9.6 |

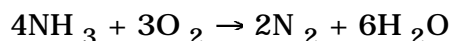
Find (i) the quantities of two layers, (ii) the mass ratio of the mixed solvent to the original mixture and (iii) the composition of the mixed solvent (mass basis). $6 + 9$



9. a) A triple effect evaporator is used to concentrate 1000 kg of aqueous solution from a concentration of 20% solute to 80% solute. Assuming an equal amount of vaporization in each effect, calculate the composition and weight of the solution entering the second and third effects.
- b) Nitric oxide is produced by the air oxidation of ammonia :



The following side reaction also occurs :

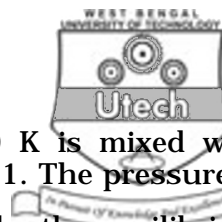


The product gases are scrubbed to remove all water and 80% of NO produced. The gases leaving the scrubber have the following analysis :

$$\text{O}_2 = 5.6\%, \text{N}_2 = 92\%, \text{NO} = 2.4\%.$$

Determine the per cent excess air used. 6 + 9

10. a) The reaction $A \rightarrow 2B + C$ takes place in a catalytic reactor. The reactor effluent is sent to a separator. The overall conversion of A is 95%. The product stream from the separator consists of B, C and 0.5% of A entering the separator, while recycle stream consists of the remainder of the unreacted A and 1% of B entering the separator. Calculate the following :
- The single pass conversion of A in the reactor
 - The molar ratio of recycle to feed.



- b) A high boiling organic liquid at 650 K is mixed with CCl_4 at 295 K in the weight ratio 1 : 1. The pressure is one standard atmosphere. What will be the equilibrium temperature of the mixture ? The heat capacity of the organic liquid and CCl_4 are given by the relations :

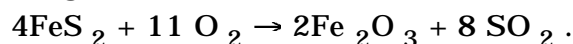
$$C_p = 0.16 + 4.78 \times 10^{-3} T,$$

$$C_p = 0.7935 + 1.298 \times 10^{-4} T \text{ respectively.}$$

C_p in kJ/kg-K and T in K. The boiling point of CCl_4 is 349.9 K and the heat of vaporization is 195 kJ/kg. The mean heat capacity of CCl_4 vapour is 0.4693 kJ/kg-K.

6 + 9

11. a) In a sulphuric acid plant, sulphur dioxide is obtained by the roasting of iron pyrites containing 80% FeS_2 and 20% gangue. Iron sulphide reacts with oxygen according to the reaction :



The cinder formed on the combustion analyzes 5% FeS_2 . Determine the standard heat of reaction per kilogram of ore, given the following standard heat of formation values at 298 K :

$$\text{FeS}_2(s) = -178.02 \text{ kJ/mol,}$$

$$\text{Fe}_2\text{O}_3(s) = -822.71 \text{ kJ/mol and}$$

$$\text{SO}_2(g) = -296.9 \text{ kJ/mol.}$$

- b) A fuel oil consisting of 10% (weight) hydrogen and 90% (weight) carbon is found to give a heat of combustion of 43000 kJ/kg, when burnt in a constant volume bomb calorimeter. Calculate the constant pressure heat of combustion of the oil.

10 + 5