Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH/BT (O)/SEM-3/BT-304/2012-13

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.

Log-Log graph sheet will be supplied by the Institute on demand.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

i) Dimension of viscosity is

a) $ML^{-1}\theta^{-1}$ b) $ML^{2}\theta^{-1}$

c) $M\theta L^{-1}$ d) $ML^{2}\theta$.

ii) Standard atmospheric pressure is equal to

a) 10 psia b) 14·7 psia

c) 33·91 ft mercury d) both (b) and (c).

iii) During temperature change of gas at constant pressure

a) Heat added = Change of internal energy

b) Head added = Change of enthalpy

c) Heat added = Change of temperature

d) none of these.

iv) Prandtl number is

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

c) hD/K d) μ / KC_p.

v) Which of the following expressions is true for ideal gases ?

a) $C_{mp} + C_{mv} = R$ b) $C_{mp} . C_{mv} = R$

c) $C_{mp} - C_{mv} = R$ d) $C_{mp} / C_{mv} = R$.

vi) Reynolds number signifies

a) inertia force / viscous force

b) gravitational force / viscous force

c) buoyancy force / viscous force

d) momentum diffusivity / thermal diffusivity.

vii) Which type of liquid mixture follows additive rule for heat capacity ?

$\left(C_{lmix} = \sum x_i . C_{li} \right)$

a) Miscible b) Immiscible

c) Both (a) & (b) d) None of these.

viii) 1 watt is equal to

a) 4·314 B.T.U./hr b) 3·41 B.T.U./hr

c) 5·61 B.T.U./hr d) 6·37 B.T.U./hr.

ix) The heat of reaction is

a) independent of temperature and pressure

b) independent of temperature but changes with pressure

c) independent of the number of intermediate steps involved

d) independent of the state of aggregation of the reactants and products.

x) The proximate analysis of coal gives

a) carbon, hydrogen, ash

b) volatile matter, moisture, ash & fixed carbon

c) carbon, hydrogen, sulphur, nitrogen

d) volatile matter, moisture, nitrogen, carbon.

xi) The wet bulb temperature of an unsaturated gas-vapour system

a) is the same as its dew point

b) is always greater than the dew point

c) is always less than the dew point

d) none of these.

xii) How many moles are there in 500 gm of oxygen ?

a) 31·25 b) 15·625

c) $9{\cdot}41 \times 10^{24}$ d) $22{\cdot}4 \times 10^{3}$.

GROUP – B

(Short Answer Type Questions)

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

2. A sample contains 25% alcohol (ethyl alcohol) in volume basis. Find the wt% of alcohol in the sample. Assume density of alcohol & alcohol free liquid to be 0·79 gm/cc & 1 gm/cc.

3. The per cent absolute humidity of air at 96°F and a total pressure of 755 mm Hg is 20%. Calculate

   a) the per cent relative humidity,

   b) the partial pressure of the water vapour in air.

   Vapour pressure of water at 96°F is 0·8403 lb/in ^{2} =

   43·44 mm Hg.

4. If 5 kg of methanol & 2 kg of ammonia are reacted to form mono-ethanolamine by the reaction

   $$CH_3OH + NH_3 \rightarrow CH_3NH_2 + H_2O$$

   a) what is the limiting reactant ?

   b) what is the % excess reactant ?

   c) recalculate (a) and (b) when diethanolamine is formed by the reaction

   $$CH_3OH + NH_3 \rightarrow (CH_3)_2NH + H_2O.$$

5. What do you mean by bubble point and dew point ? Describe briefly with graphical representation.

6. By electrolyzing a mixture of brine, a mixture of gases is obtained in cathode having the following percentage by weight Cl_2 – 67%, Br_2 – 28%, O_2 – 5%. Using the ideal gas law calculate (i) composition of the gas by volume, (ii) density of the mixture in grams per litre at 25°C and 740 mm of mercury pressure.

GROUP – C

(Long Answer Type Questions)

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

7. a) $N_2 - H_2$ mixture with a molar ratio of 1 : 3 is used for the manufacture of NH_3, where 18% conversion is achieved. After separating NH_3 from the product, the unconverted gases are recycled. The feed contains 0·2 mole of argon per 100 moles of $N_2 - H_2$ mixture. The tolerance limit of argon entering the reactor is 6 parts to 100 parts of $N_2 - H_2$ mixture by volume. Calculate

   i) the fraction of recycle that must be continuously purged

   ii) the overall yield of ammonia.

   b) Define the following terms :

   i) Limiting reactant ii) % Excess

   iii) Selectivity iv) Purging.

   c) Air is pumped through an orifice immersed in liquid. The size of the bubbles leaving the orifice depends on the diameter of the orifice and the properties of the liquid. The equation representing the situation is

$$\frac{g\left(\rho_L - \rho_g\right) D_b^3}{\sigma D_o} = 6$$

where g = Gravitational acceleration = 32·174 ft/s^2,

ρ_L = liquid density = 1 g/c.c.

ρ_g = gas density = 0·081 lb/ft^3 ,

D_b = bubble diameter,

σ = gas-liquid surface tension = 70·8 dyne/cm,

D_o = orifice diameter = 1 mm.

Calculate the bubble diameter D_b . 6 + 6 + 3

8. a) The following data have been gathered from an experiment meant to determine the relationship which exists between the diameter of a ring and its period of oscillation as a pendulum. Each diameter was measured, and each period was determined by measuring the number of cycles per unit of time.

Ring diameter (cm)	3·51	7·26	13·7	28·5	38·7
Time period (Sec)	0·374	0·532	0·768	1·08	1·32

These data follow a relationship of the form $T = Ad^n$ where T is the period of oscillation, A is the constant of proportionality, d is the diameter of the ring, and n is a constant. Find out the values of A and n using log-log graph paper.

b) Production of single cell protein from hexadecane is described by the following reaction equation :

$$C_{16}H_{34} + aO_2 + bNH_3 \rightarrow cCH_{1\cdot66}O_{0\cdot27}N_{0\cdot20} + dCO_2 + eH_2O$$

where $CH_{1\cdot66}O_{0\cdot27}N_{0\cdot20}$ represent the biomass. If $RQ = 0\cdot43$, determine

i) the stoichiometric coefficients

ii) the yield coefficients $Y_{x/S}$ and Y_{x/O_2}

iii) the degree of reduction for the substrate and bacteria. 9 + 6

9. a) Heat capacity of gaseous SO_2 is governed by the following equation :

$C_{mp} = 43{\cdot}46 + 10{\cdot}6 \times 10^{-3} \, . \, T - 5{\cdot}95 \times 10^{5} \, . \, T^{-2}$ kJ/(kmole.K)

Calculate the heat required to raise the temperature of 6·4 kg SO_2 from 27°C to 727°C.

b) Chlorinated diphenyl (a liquid) is heated from 313 K to 553 K. Heat capacity of this liquid is governed by :

$C_1 = 0{\cdot}75 + 1{\cdot}4 \times 10^{-3} \, . \, T$ kJ/(kg.K)

i) Calculate heat required to raise the temperature of 1 kg chlorinated diphenyl.

ii) Heat capacity of Chlorinated diphenyl at 313 K and 553 K is 1·18 kJ/(kg.K) and 1·52 kJ/(kg.K) respectively. Calculate the percentage error involved in using heat capacity data for heat change calculation. 7 + 8

10. a) 1000 kg of an impure limestone which analyses 96% $CaCO_3$ and 4% inert material is reacted with a sulphuric acid solution containing 70% sulphuric acid and 30% water. The reacting mass is heated and all the CO_2 generated is driven off together with some of the water. The analyses if the final solid 'cake' is

$CaSO_4$	86·54%
$CaCO_3$	3·11%
H_2SO_4	1·35%
H_2O	6·23%
Inerts	2·77%

Calculate (i) the degree of completion of the reaction, (ii) mass of acid solution fed.

b) Write short notes on

i) Degree of reduction in microbial growth

ii) Biomass yield.

c) Check the dimensional homogeneity of the following equation :

$Q = C_d A (2gH)^{1/2}$ where, Q = volumetric flow rate, C_d = drag coefficient (dimensionless), g = gravitational acceleration, H = difference in height, A = area.

7 + 5 + 3

11. Derive the equation by Buckingham P_i method for the case of the force exerted on a body immersed in a fluid, where F (force), is the function of L (length), V (velocity) of the body passing through the fluid, P is density of fluid medium, μ is viscosity of the medium.