Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(New)/BT(N) & FT(N)/SEM-4/CH-401/2012

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.

Semilog graph sheet is supplied by the Institute.

GROUP – A

(Multiple Choice Type Questions)

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

i) Which of the following is not equivalent to 1 standard atmospheric pressure ?

a) 1·01325 bar

b) 1·01325 pa

c) 760 mm Hg

d) $1{\cdot}01325 \times 10^5$ N/m^2.

ii) Which one of the following statement is correct regarding g_c, the Newton's law conversion factor ?

a) It is a dimensionless constant

b) It is numerically equal to g, the local acceleration due to gravity

c) Weight of a body is equal to the product of mass and g_c

d) Numerical value of g_c are different for different systems of unit.

iii) A mole of compound contains

a) one molecule of the substance

b) one atom of substance

c) $6{\cdot}023 \times 10^{23}$ molecules

d) $22{\cdot}4 \times 10^{3}$ molecules.

iv) Pure oxygen is mixed with air to produce an enriched air containing 50 volume % of O_2. The ratio of moles of air to oxygen is

a) 1·72 b) 0·58

c) 0·5 d) 0·2.

v) The molarity of water in pure water is

a) 1 b) 18

c) 55·55 d) infinity.

vi) The saturation temperature of pure substance is generally known as

a) the critical temperature

b) the three phase temperature

c) the triple point

d) the boiling point.

vii) In a dilute solution

a) the solute obeys Henry's law

b) the solute and solvent obeys Henry's law

c) the solute obeys Raoult's law

d) the solvent obeys Henry's law.

viii) Enthalpy of a particular substance is expressed as

a) internal energy + (pressure × volume)

b) (internal energy × pressure) + volume

c) (internal energy × volume) + pressure

d) none of these.

ix) When two liquids are mixed up

a) the heat effect is termed as heat of mixing

b) the heat effect is termed as heat of solution

c) the heat effect is termed as heat of dissolution

d) none of these.

x) Heat capacity of a substance is defined as

a) quantity of heat supplied to rise in one degree of temperature

b) quantity of heat released to rise in one degree of temperature

c) quantity of heat absorbed to rise in one degree of temperature

d) none of these.

GROUP – B

(Short Answer Type Questions)

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

2. 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 pi theorem.

3. 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.

4. Find the Orsat analysis of the burner gas when pure sulpher is burned with 20% excess air. Of the sulpher burned, 5% is converted to SO_3 and the rest to SO_2.

5. a) Define standard heat of reaction.

   b) Calculate the standard heat of the following reaction at 298K :

   $C_5H_{12}(g) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(g)$.

   The standard heats of formation are followed as :

   $CO_2(g) = -391{\cdot}51$ kJ, $H_2O(g) = -241{\cdot}826$ kJ, $C_5H_{12}(g) = -146{\cdot}4$ kJ. The latent heat of vaporization of water at 298°K is 43·967 kJ/mol.

   1 + 4

6. 250 kg wet ammonium sulphate containing 50 kg moisture is sent to a dryer in order to remove 90% of the moisture in the feed. Calculate for the entrance and exit to the dryer, following :

   a) wt. fraction of water

   b) wt. ratio of water

   c) wt.% of moisture on wet and dry basis. 1 + 1 + 3

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. 3 × 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 semilog graph paper :

Time (hr)	1	2	3	4	5	6
Conc. of drug (mg/cc)	2·25	1·143	0·63	0·396	0·279	0·09

8. a) A crystallizer is charged with 100 kg of a solution containing 25% $Ba(NO_3)_2$ 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 $Ba(NO_3)_2$ / 100 kg total water.

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 composition of two layers are given below :

	Composition, mass %			
Layer	A	B	S1	S2
Upper layer	7·5	3·5	57·4	3·16
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

iii) the composition of the mixed solvent (mass basis).

6 + 9

9. Carbon monoxide and hydrogen reacts to given methanol : $CO + 2H_2 \rightarrow CH_3OH$. The conversion of CO entering the reactor is only 20%. A feed stream consisting of 33% CO, 66.5% H_2 and 0.5% methane is mixed with a recycle stream and sent to a reactor. The methanol leaving the reactor is separated and the unconverted gases are recycled. To prevent the accumulation of CH_4 and keep its concentration in the recycle stream at 3%, a portion of a recycle stream is blown off. For 100 moles of fresh feed, determine the following :

a) the mole of recycle stream

b) the moles of purge stream

c) the composition of the purge stream

d) the moles of methanol produced.

10. a) Coal having the following analysis on a weight basis has a gross heating value of 29000 kJ/kg : Carbon 70% hydrogen 5.5%, nitrogen 1.5%, sulpher 3%, oxygen 13% and ash 7%. Calculate the net heating value given that the latent heat of vaporization of water is 2370 kJ/kg water.

b) Heat is transferred to 10 kg of air which is initially at 100 kPa and 300 K unit its temperature reaches 600 K. Determine the change in internal energy, the change in enthalpy, the heat supplied and the work done in the following processes :

i) constant volume process

ii) constant pressure process

Assume that air is an ideal gas.

Take C_p = 29·0999 kJ/kmol K and
C_v = 20·785 kJ/kmol K. 7 + 8

11. a) A spherical storage tank of 3 metre diameter is half-filled with 12500 kg of an organic liquid at 7000 kPa. If the total internal energy in the tank is $5{\cdot}3 \times 10^6$ kJ, what is the specific enthalpy of the fluid in the tank ?

b) The heat capacity of CO_2 is given by the following relation :

$C_p = 26{\cdot}540 + 42{\cdot}454 \times 10^{-3} T - 14{\cdot}298 \times 10^{-6} T^2$ where, C_p is in kJ/kmol K and T is in K.

i) How much heat is required to heat 1 kg of CO_2 from 300 to 1000 K at constant pressure ?

ii) Obtain the relation expressing the heat capacity kcal/kmol°C and tempereature in °C.

iii) Obtain the relationship giving heat capacity in Btu/lb-mol°F and temperature in °F. 5 + 10