Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/B.Tech(CHE)/SEM-3/CHE-301/2010-11

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 any *ten* of the following : $10 \times 1 = 10$

i) Which of the following ratios defines the recycle ratio in a chemical process ?

a) Gross feed stream / recycle feed stream

b) Recycle stream / fresh feed stream

c) Recycle stream / gross feed stream

d) None of these.

ii) An equation for calculating vapour pressure is given by, $\log_{10} P = A - B / (t + c)$. This is called

a) Kistyakoswky equation

b) Antoine equation

c) Kopp's rule

d) Trouton's rule.

iii) Boiling point of a solution as compared to that of the corresponding solvent is

a) less

b) more

c) same

d) either more or less ; depends upon the nature of the solvent.

iv) Specific gravity on API scale is given by the relation

a) ^{0} API = 200 (G – 1)

b) ^{0} API = (141·5 / G) – 131·5

c) ^{0} API = (140 / G) – 130

d) ^{0} API = 145 – (145 / G)

where, G = specific gravity at 15·5°C.

v) A 'limiting reactant' is the one which decides the …………… in the chemical reaction.

a) equilibrium constant b) conversation

c) rate constant d) none of these.

vi) Which of the following expressions defines the Baume gravity scale for liquids lighter than water ?

a) ^{0} Be = (140 / G) – 130

b) ^{0} Be = 200 (G – 1)

c) ^{0} Be = 145 – (145 / G)

d) ^{0} Be = (400 / G) – 400.

vii) Which of the following expressions defines the Baume gravity scale for liquids heavier than water ?

a) (141·5 / G) – 131·5

b) 145 – (145 / G)

c) 200 (G – 1)

d) (400 / G) – 400.

viii) 'Cox' chart which is useful in the design of distillation column (particularly suitable for petroleum hydrocarbons) is a plot of

a) temperature *vs* log (vapour pressure)

b) vapour pressure *vs* log (temperature)

c) log (temperature) *vs* log (vapour pressure)

d) vapour pressure *vs* temperature.

ix) Which law states the statement 'the net heat change will be the same whether the chemical process occurs in one or in several stages' ?

a) Law of Lavoisier and Laplace

b) Hess's law

c) Both (a) and (b)

d) Neither (a) nor (b).

x) Enthalpy is

a) independent of composition

b) a path function

c) independent of temperature and pressure

d) a state function.

xi) The enthalpy of saturated steam and saturated liquid water at 101·325 kPa and 100°C are 419 and 2256 kJ/kg, respectively. The latent heat of vaporization of the saturated water at the same temperature and pressure is

a) 2675 kJ/kg b) 1837 kJ/kg

c) 4512 kJ/kg d) none of these.

xii) The adiabatic cooling lines are the same as

a) the wet bulb lines b) psychrometric lines

c) both (a) and (b) d) none of these.

GROUP – B

(Short Answer Type Questions)

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

2. Air contains 21% O_2 and 79% N_2 by volume. Calculate the composition in terms of % by weight and its density at a pressure of 735·56 mm of Hg and a temperature of 25°C. Assume air to behave as an ideal gas.

3. State and explain the principles used in Humidity Chart.

4. A cylinder contains 14·2 kg of liquid propane. What volume in litres will the propane occupy if it is released and brought to standard conditions ?

5. Explain API scale and Twaddel scale.

6. What do you mean by a adiabatic flame temperature ? Calculate the heat that must be added to 3 kmol air to heat it from 298 K to 473 K using mean molal heat capacity data for air as mentioned below

   C_P = 29·3955 kJ/kmol.K.

GROUP – C

(Long Answer Type Questions)

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

7. The power requirement '*P*' for an agitator is dependent on the propeller diameter '*D*', its rotational speed '*N*', the liquid density 'ρ' and viscosity 'μ' and the gravitational acceleration '*g*'.

   i) From dimensional analysis using Buckingham's method, obtain a relation between power and the four variables.

   ii) The power consumption is found experimentally to be proportional to the square of the speed of rotation. By what factor would the power be expected to increase if the impeller diameter was doubled ? 15

8. For a chemical reaction the concentration, C is related to the time of reaction θ by an equation :

$$C = C_0 \; e^{-k\theta}$$

Find values of C_0 and k from the following data :

Time* θ *min	0	30	60	90	130	180
Conc., C gm mole/lit	5·012	4·511	4·039	3·627	3·419	2·674

15

9. a) The gas entering a secondary convertor in a contact H_2SO_4 plate at 400°C, 758 mm Hg pressure contains 4% SO_2, 13% O_2 and 83% N_2 on SO_3 free basis. Calculate —

   i) densities of gases entering and leaving the secondary convertor.

   ii) % SO_2 converted to SO_3 in the secondary convertor.

   iii) volume of gases leaving the secondary convertor per kg of sulphur burnt. $7\frac{1}{2}$

   b) The off-gas from a phosphate reduction furnace, analyze P_4, 10%, CO, 87% and N_2, 3% on a volume per cent basis and is burnt with air under conditions such that phosphorus is selectively oxidized. From the flue gas, the oxides of phosphorus precipitate on cooling and are separated from the remaining gas, analysis of the latter shows CO_2, 0·9% ; CO, 22·5% ; N_2, 69·0% and O_2, 8·6%.

   It may be assumed that the oxidation of phosphorus is complete and the phosphorus exists in the flue gases partly as P_4O_6 and partly as P_4O_{10}.

   Calculate :

   i) What percentage of CO entering the burner is oxidized to CO_2 ?

   ii) What percentage of P_4 is oxidized to P_4O_{10} ? $7\frac{1}{2}$

10. A producer gas made from coke has this composition by volume : CO-28·0%, CO_2 -3·5%, O_2 -0·5% and N_2 -68·0%. The gas is burnt with such a quantity of air that the O_2 form the air is 30% in excess to the net oxygen demand for complete combustion. If the combustion is 96% complete, calculate the weight and composition in volume per cent of the gaseous product formed per 100 kg of gas burnt. 15

11. Water gas is produced by passing steam over a hot bed of coke at 1000°C

$$C + H_2O \varnothing CO + H_2$$

$$CO + H_2O \varnothing CO_2 + H_2 .$$

Estimate the consumption of coke and steam for the production of 1000 m^3 of water gas containing 55·4% H_2, 44·0% CO, and 0·6% CO_2 by volume. Coke contains 90% C by weight and the yield is 90%. 15