

INDUSTRIAL STOICHIOMETRY
(BTC2232)

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) 2 litres of nitrogen at N.T.P. weighs _____ gms
 - (a) 2.5
 - (b) 1.25
 - (c) 28
 - (d) 14
- (ii) The degree of freedom of a binary mixture of ethanol and water is
 - (a) more than 1
 - (b) less than 1
 - (c) 0
 - (d) cannot be determined
- (iii) Which of the following does the concept of material balance based upon?
 - (a) Conservation of mass
 - (b) Conservation of energy
 - (c) Conservation of momentum
 - (d) Conservation of volume
- (iv) What is the average molecular weight of a gas containing 20% N₂ (molecular wt. = 28) and 80% SO₂ (molecular wt. = 64)?
 - (a) 28.4
 - (b) 56.8
 - (c) 24.4
 - (d) 48.8
- (v) Sometimes, in chemical processes, a part of the outlet stream is rejected as waste in order to keep the impurity level in the system within limits. This phenomenon is termed as the
 - (a) Recirculation
 - (b) Bypassing
 - (c) Recycling
 - (d) purging

- (vi) When the temperature of a binary mixture is more than its dew point then it is a
 - (a) Saturated liquid mixture
 - (b) Subcooled liquid mixture
 - (c) Equilibrium vapour liquid mixture
 - (d) Superheated vapour mixture
- (vii) The temperature at which the first drop of liquid is formed is known as
 - (a) Bubble point
 - (b) Dew point
 - (c) Critical point
 - (d) Supercritical point
- (viii) The amount of heat released during consumption of one gmol of oxygen is
 - (a) 115Kj
 - (b) 460kj
 - (c) 0
 - (d) None of the above
- (ix) When a system allows flow of energy between system and surrounding is a
 - (a) closed system
 - (b) isolated system
 - (c) open system
 - (d) all the above
- (x) A high degree of reduction indicates
 - (a) a higher rate of loss of electrons
 - (b) a high degree of acceptance of oxygen
 - (c) inertness of material
 - (d) a low degree of oxidation

Fill in the blanks with the correct word

- (xi) In distillation, more volatile component is obtained from _____ part of column
- (xii) Material balance is a law of conservation of _____.
- (xiii) In a particular reaction, one of the reactants limits the amount of products formed. That is called as _____.
- (xiv) The amount of water produced when 8g of hydrogen is reacted with 32g of oxygen is _____.
- (xv) For a gaseous mixture, composition of the components in volume fraction is equal to _____.

Group - B

2. (a) 2m^3 of O_2 at 200 KPa and 280K is mixed with 10kg of N_2 at 95KPa and 300K and the resulting mixture is brought to 110KPa and 280 K.
 - (i) What is the partial pressure of O_2 in the final mixture.
 - (ii) What is the final volume of the mixture? [[CO2](evaluate/IOCQ)]
 - (b) Prove that volume composition of an ideal gas mixture is same as molar composition of that mixture? [[CO2](Remember/LOCQ)]
- (4 + 2) + 6 = 12**
3. Natural gas is piped from a well at 300K and 400KPa. The gas is found to contain 93% ethane, 4.5% ethane and rest nitrogen. Calculate the following:
 - (i) Partial pressure of nitrogen.

- (ii) The pure component volume of ethane in 10 m³ of gas.
- (iii) The density of gas at standard condition
- (iv) Composition in weight percentage.

[[C01](Analyse/IOCQ)]
(2 + 2 + 2 + 6) = 12

Group - C

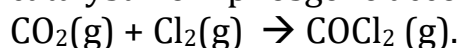
4. In a process of Cl₂ manufacture, a dry mixture of HCl gas and air is passed over a heated catalyst which promotes oxidation of the acid. Air is used in 30% excess of that stoichiometrically required.

Calculate

- (i) Weight of air supplied per kg of acid.
- (ii) Composition by weight of gas entering the reaction chamber.
- (iii) Assuming that 60% of the acid is oxidised in the process, calculate the composition by weight of the gas leaving the chamber.

[[C03](Compute/IOCQ)]
(4 + 4 + 4) = 12

5. (a) Compare Carbon monoxide combines with chlorine in the presence of a suitable catalyst from phosgene according to the following reaction.



After reaction, the product contained 12 moles of phosgene, 3 moles of chlorine and 8 moles of carbon- mono- oxide. Assuming that the original reactant mixture is free of phosgene, calculate the following.

- (i) The percentage excess reactant used.
- (ii) The present conversion of the limiting reactant.
- (iii) The moles of total product per mole of reactant mixture fed to the reactors.

[[C03](Analyse/IOCQ)]

- (b) Define (i) Limiting reactant (ii) percentage conversion of reactant?

[[C03](Remember/LOCQ)]
(3 + 3 + 3) + 3 = 12

Group - D

6. (a) Calculate the energy required to dissociate a kilogram of sodium bicarbonate into sodium carbonate, carbon-di-oxide and water at 298K.

Heat of formation of sodium bicarbonate, kJ/mol	Heat of formation of sodium carbonate, kJ/mol	Heat of formation of carbon di oxide, kJ/mol	Heat of formation of water, kJ/mol
-950.81	1130.68	-393.51	-241.82

[[C03](Analyse/IOCQ)]

- (b) A thermic fluid is used as a heating medium in a particular process. A pump sucks the thermic fluid at atmospheric pressure and 473K. The circulation rate is 10,000lph. The fluid discharged from the pump, passes through a heater where it receives the heat from product gases of combustion. The heat transfer rate is 232.6kW. The motor of the pump consumes 1.1kW. The overall mechanical

efficiency of the pump and motor is 50%. The pressure of the fluid at the outlet of the heater is 100kPag. Assume negligible kinetic energy and potential energy changes, negligible frictional losses and no heat loss to the surrounding. If the mean specific gravity and the mean heat capacity of the fluid are 0.75 and 2.68kJ/(kg.K) respectively at the operating conditions, calculate the outlet temperature of the fluid.

[[CO2](Calculate/IOCQ)]

4 + 8 = 12

7. A mixture of diphenyl-diphenyloxides (Diphyl DT) is used as a thermic fluid in a liquid phase heating system. The thermic fluid enters an indirect fired heater at 453K and leaves it at 533K. The heat capacity of the fluid is given by $C = 1.436 + 0.00218T$ kJ/kg.K where T is in K.

- (i) Calculate the supply of heat in the heater per kg of the liquid heated.
 (ii) If the heat capacity of Diphyl DT at 453K and 533K are 2.03 and 2.206kJ/kg.K respectively, how much error will be involved in the computation of heat load using the mean heat capacity value?

[[CO4](Analyse/HOCQ)]

(6 + 6) = 12

Group - E

8. *Azetobacter vinelandii* is used to produce alginate in a continuous reactor from sucrose at room temperature. The yield of alginate was 4g/g of O₂ consumed. The required rate of alginate production was 5kg/h. The mechanical energy requirement to run the reactor could not be neglected and power requirement was estimated to be 1.5kW. Estimate the cooling requirements. (Energy released per gmole of electron transferred = -115kJ)

[[CO2](Apply/IOCQ)]

12

9. (a) Define the following terms:- Heat of reaction, metabolic heat generation, elementary reaction.
 (b) Illustrate the step by step approach to indirectly determine heat of formation of a compound.

[[CO5](Remember/LOCQ)]

[[CO5](Remember/LOCQ)]

(2 × 3) + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	21.87	65.63	12.50