

**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) Pick out the correct conversion
(a) 1 BTU = 453.6 calories (b) 1 calorie = 252 BTU
(c) 1 BTU = 252 calories (d) 1 calorie = 453.6 BTU
- (ii) For a gaseous mixture, composition of the components in volume percent is equal to their composition
(a) in weight percent (b) in mole percent
(c) in weight percentage (d) none of these
- (iii) Dimension of volumetric flow rate
(a) L^3T^{-1} (b) L^2T^{-2}
(c) MT^{-1} (d) LT^{-1}
- (iv) With reference to the following reaction, if 100 g of N_2 and 100 g of H_2O are mixed and the maximum possible reaction occurs, what mass of O_2 is produced?
 $2N_2 + 6H_2O = 4NH_3 + 3O_2$
(a) 100 (b) 171
(c) 88.9 (d) 2.78
- (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 less than its bubble point then it is a
(a) Saturated liquid mixture (b) Equilibrium vapour liquid mixture
(c) Saturated vapour mixture (d) Subcooled liquid mixture
- (vii) An Ideal liquid solution follows
(a) Raoult's Law (b) Modified Charles Law
(c) Boyle's Law (d) None of these

- (viii) Which of the following statement is True?
 (a) Change in internal energy equals the work added in a constant volume process.
 (b) In constant pressure process heat transferred is equal to the entropy of the body.
 (c) $C_p dT = dE + P dV$, E is internal energy.
 (d) $C_v dT = dE + P dV$, E is the internal energy.
- (ix) The amount of heat required to increase the temperature of unit mass of a substance by 1°C is its
 (a) heat capacity (b) specific heat
 (c) both (a) and (b) (d) None of the above
- (x) Degree of reduction of ethyl alcohol is
 (a) 2 (b) 4 (c) 6 (d) 8

Fill in the blanks with the correct word

- (xi) Degree of reduction of $\text{CH}_{1.8}\text{O}_{0.5}\text{N}_{0.2}$ with respect to nitrogen is _____.
- (xii) Material balance is a law of conservation of _____.
- (xiii) 7. 56 grams of carbon monoxide is oxidized with excess oxygen, then mass of carbon dioxide that will it produced is _____.
- (xiv) The line that helps to calculate the ratio of amount of vapour to amount of liquid in a VLE curve is known as _____ q-line _____.
- (xv) Unit of heat capacity of a gas is _____.

Group - B

2. An ideal gas mixtures has the following stoichiometric analysis.

Component	% by mass
N_2	40
CO_2	10
CO	13
O_2	17
H_2	8
CH_4	12

- (i) Find the analysis on a volume basis
 (ii) What is the volume of 1 kg of this gas when pressure = 1.5 MPa and $T=30^\circ\text{C}$.

[[CO2](Analyse/IOCQ)]
(8 + 4) = 12

3. (a) A solution of NaCl in water contains 20% NaCl (by mass) at 333K. The density of the solution is 1.127 Kg/L. Find the molarity, normality and molality of the solution?
 (b) Prove that volume composition of an ideal gas mixture is same as molar composition of that mixture?

[[CO2](Remember/LOCQ)]
(2 + 2 + 2) + 6 = 12

Group - C

4. (a) The chlorination of methane occurs by the following reaction.
 $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl}$
 Determine the product composition in mol% if the conversion of the limiting reactant is 67%, and the feed contains 40 gmol CH_4 , 50 gmol Cl_2 , and 10 gmol N_2 .
[[CO3](Analyse/IOCQ)]
- (b) Antimony is obtained by heating pulverised stibnite (Sb_2S_3) with scrap iron and drawing antimony (Sb) from the bottom of the reactor vessel.
 $\text{Sb}_2\text{S}_3 + 3\text{Fe} \rightarrow 2\text{Sb} + 3\text{FeS}$
 Suppose that 0.600 Kg of stibnite (Sb_2S_3 , MW= 340) and 0.25 Kg of Fe (MW =56) are heated together to give 0.20 Kg of Sb metal (MW =121.8), determine
 (i) Which reactant is Limiting reactant?
 (ii) % excess reactant?
[[CO4](Compute/LOCQ)]
6 + 6 = 12
5. (a) 1134 litre of a mixture containing 75wt% ethanol and 25wt % water (Specific gravity = 0.877) and a quantity of 40 wt% ethanol with 60 wt% water (specific gravity =0.952) are blended to produce a mixture containing 60 wt % ethanol. Determine the volume of mixture that contains 40wt% ethanol. *[[CO2](Analyse/HOCQ)]*
- (b) A binary mixture of 35% benzene and 65% toluene are continuously distilled fed to a distillation column at a rate of 1000kg/hr. The distillate flow rate is 10% of the feed flowrate. The distillate contains 85% benzene. Calculate the quantity and composition of the waste stream.
[[CO3](Remember/LOCQ)]
6 + 6 = 12

Group - D

6. 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
7. Calculate the heat of formation of the following compounds at 298K using data on heats of combustion- i) gaseous n-heptane, ii) gaseous ethyl alcohol and iii) liquid 1,3-butadiene. Heat of combustion for:
 gaseous n-heptane= -4501.3kJ/mol
 gaseous ethyl alcohol= -1278.04kJ/mol
 liquid 1,3-butadiene= -2522.1kJ/mol.
[[CO4](Calculate/IOCQ)]
(4 + 4 + 4) = 12

Group - E

8. Citric acid is manufactured using submerged culture of *Aspergillus niger* in a batch reactor operated at 30°C. Over a period of two days, 2500kg of glucose and 860kg of oxygen are consumed to produce 1500kg citric acid, 500kg biomass and other products. Ammonia is used as nitrogen source. Power input to the system by mechanical agitation of the broth is about 15kW; approximately 100kg of water is evaporated over the culture period. Estimate the cooling requirements. Latent heat of vapourization of water at 30°C is 2430.7kJ/kg.

[[CO6](Calculate/HOCQ)]

12

9. (a) Fumaric acid and water are produced from malic acid using the enzyme fumarase. Calculate the standard heat of reaction for the above enzyme transformation.
Heat of combustion of :
Malic acid = -1328.8kJ/gmol
Fumaric acid = -1334kJ/gmol.
- (b) Define the following terms:- Heat of reaction, metabolic heat generation, elementary reaction.

[[CO5](Calculate/IOCQ)]

[[CO5](Remember/LOCQ)]

6 + (2 × 3) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	31.25	37.50	31.25