UTKALMANI GOPABANDHU INSTITUTE OF ENGINEERING, ROURKELA

LESSON PLAN

DEPARTMENT OF CHEMICAL ENGINEERING

LESSON PLAN

SUBJECT CODE : TH-4

NAME : Stoichiometry

BRANCH : CH

SEMESTER :Diploma-III

CREDIT POINTS : 4

NUMBER OF MODULES : 4

CLASSES REQUIRED : 60

PRE-REQUISITE : TO UNDERSTAND UNITS AND DIMENSIONS, DIMENSIONAL ANALYSIS, MATERIAL BALANCE EQUATION, ABLE TO CALCULATE DENSITY, SPECIFIC GRAVITY ETC. OF GASEOUS MIXTURES, ENERGY REQUIREMENT FOR A CHEMICAL PROCESS FROM ENERGY BALANCE EQUATION

MODULE-I

Syllabus –
UNITS AND DIMENSIONS: 1. Basic and derived units used in process industry. 2 Solve numerical on unit conversion from one unit to SI unit. 3 Dimension and application of dimensional analysis. 4 Different graphs used in industry

Objectives:

To able to differentiate between different units and dimensions, dimensional analysis and solve relevant problems

Session no	Topics to be covered	PRIMARY REFERENCE (BOOKS/NOTES)	EXPECTED QUESTIONS TO BE DISCUSSED
1	Basic and derived units used in process industry	R1	Q.A.(1-2)
2	Numerical problems on unit conversion from one unit to SI unit	T1,R1	
3	Dimension and application of dimensional analysis. Different graphs used in industry	T1	

MODULE-II

MOLE CONCEPT: 1. Mole, mole fraction, mass fraction, 2. Mole concept with respect to chemical equation, 3. Principle of atom conservation, 4. Elementary problems on mole concept, 5. Methods of expressing composition of mixtures and solutions

Objectives:

To calculate mole, mole fraction, mass fraction of mixture. To understand principle of atom conservation and able to solve elementary problems on mole concept.

Session no	Topics to be covered	PRIMARY REFERENCE (BOOKS/NOTES)	EXPECTED QUESTIONS TO BE DISCUSSED
4	Definition and problems on Mole, mole fraction, mass fraction	T1, R1	Q.A.(3-7) Q.B.(1-2) Q.B.5
5	Mole concept with respect to chemical equation and problems solving	T1,R1,T2	
6	Principle of atom conservation with example	T1	
7	Methods of expressing composition of mixtures and solutions	T1, R1	
8	Problem solving on composition of mixtures and solutions	R1	

MODULE-III

STOICHIOMETRY: 1. Stoichiometry, 2. Basis of Calculation, 3. Concept of limiting reactants, 4. Atomic weight, molecular weight, molecular formula, empirical formula and solve some problems on it, 5. Solve problems on chemical reaction on mass-mass, mass-volume basis

Objectives:

To understand basis of calculation and concept of limiting reactants. To be solve problems on atomic weight, molecular weight, molecular formula, empirical formula.

Session no	Topics to be covered	PRIMARY REFERENCE (BOOKS/NOTES)	EXPECTED QUESTIONS TO BE DISCUSSED
9	Definition of stoichiometry,	T1, R1	Q.A.8

	stoichiometry ratio.		Q.B.9 Q.C.2
10	Definition of basis of calculation with examples	T1	
11	Problems on basis of calculation.	T1,R1	
12	Concept of limiting reactants with examples	T2	
13	Problems on limiting reagent		
14	Definition of Atomic weight, molecular weight and problems solving	T1,R1	
15	Definition of empirical formula, examples and problems solving	T1	
16	Concept on chemical reaction on mass-mass basis	T1	
17	Concept on chemical reaction on mass-volume basis	T1	
18	Definition of molecular formula, examples and problems solving	T1, R1	
19	Concept of excess reactants with examples	T1,R1	
20	Problems on excess reagent	T1,R1,T2	
21	Problem on chemical reaction on mass-mass basis	T1,R1	
22	Problem on chemical reaction on mass-volume basis	T1,R1	
23	Revision and Quiz	T1,R1,T2	

MODULE-IV

GASES AND GASEOUS MIXTURES: 1. Ideal gas law, 2. Average molecular weight, density and composition (by weight and volume) of gas mixture and solve problems on it , 3. Partial pressure, Vapour pressure, Amagat's law, Dalton's law and solve problems on it, 4. State Roult's law and Henry's law and solve problems.

Objectives:

To understand ideal gas law, partial pressure, vapour pressure, Amagat's law, Dalton's law, Roult's law and Henry's law. To be able to solve problems on density and composition (by weight and volume) of gas mixture, Amagat's law, Dalton's law, Roult's law and Henry's law.

Session no	Topics to be covered	PRIMARY REFERENCE (BOOKS/NOTES)	EXPECTED QUESTIONS TO BE DISCUSSED
24	Definition of Ideal gas law, limitations of Ideal gas law STP and NTP conditions	T1,R1	Q.A.(9-16) Q.B.(6-8)
25	Problem solving on Ideal gas law	T1	
26	Derivation of Average molecular weight and problem solving	T1,R1	
27	Derivation of density for gas mixture and problem solving	R1	
28	Composition (by weight and volume) of gas mixture and problem solving	T1,T2	

29	Definition of partial pressure, vapour pressure, Dalton's law and Amagat's law	T1,R1	
30	Problem solving on partial pressure, vapour pressure	T1	
31	Problem solving on Dalton's law and Amagat's law	R1	
32	Definition of Roult's law and its limitations	R1	
33	Definition of Henry's law and its limitations	T1,R1	
34	Problem solving on Roult's law and Henry's law	T1	
35	Revision and Quiz test	R1	

MODULE-V

MATERIAL BALANCE WITHOUT CHEMICAL REACTION: 1. State Law of conservation of mass, 2. Concept of material balance, 3. Solve problems on material balance based on Unit operations like mixing, evaporation, distillation, drying, humidification, extraction, absorption

Objectives:

To understand concept of material balance and law of conservation of mass. To be able solve problems on problems on material balance based on Unit operations like mixing, evaporation, distillation, drying, humidification, extraction, absorption

Session no	Topics to be covered	PRIMARY REFERENCE (BOOKS/NOTES)	EXPECTED QUESTIONS TO BE DISCUSSED
36	State Law of conservation of mass, Concept of material balance	T1, R1	Q.A.(17-23) Q.10.(10-12) Q.C.1
37	Material balance, component Balance equations on mixing (Two stream) and problem solving	T1	
38	Material balance, component Balance equations on mixing (Three stream) and problem solving	R1	
39	Material balance, component Balance equations on evaporation	T1,R1	
40	Problem solving based on material balance on evaporation.	R1	
41	Material balance, component Balance equations on distillation	T1, R1	
42	Problem solving based on material balance on distillation	T1,R1	
43	Material balance, component Balance equations on drying and problem solving	T1	
44	Material balance, component Balance equations on humidification and problem solving	T1,R1	
45	Material balance, component Balance equations on extraction.	T2,R1	
46	Problem solving based on material balance on extraction	T1	

47	Material balance, component Balance equations on absorption	R1	
48	Problem solving based on material balance on absorption	T1	
49	Material balance, component Balance equations on crystallizer cum evaporator and problem solving	T1,R1	
50	Material balance, component Balance equations on oil seed extraction and problem solving	T1,T2	

MODULE-VI

MATERIAL BALANCE INVOLVING CHEMICAL REACTION, 1. Law of conservation of mass, 2. Stoichiometric ratio, Stoichiometric proportions, excess reactants, percentage excess, conversion, yield, selectivity, 3. Concept and reaction mechanism in combustion, 4. Solve problems on material balance with chemical reaction and combustion, 5. Concept of recycle and by pass, 6. Combustion, Excess air, Problems related to combustion

Objectives:

To understand the terms like stoichiometric ratio, stoichiometric proportions, excess reactants, concept and reaction mechanism in combustion. To able to calculate percentage excess, conversion, yield, selectivity, material balance with chemical reaction and combustion.

Session no	Topics to be covered	PRIMARY REFERENCE (BOOKS/NOTES)	EXPECTED QUESTIONS TO BE DISCUSSED
51	Law of conservation of mass	T1, R1	Q.A.(24-30) Q.B.(13-16)
52	Definition of Stoichiometric ratio, Stoichiometric proportions, excess reactants, percentage excess, conversion, yield, selectivity and their formulas	T1,R1	
53	Problem solving on excess reagents and percentage excess.	T1,T2	
54	Problems solving on yield and selectivity.	T1,R1	
55	Concept and reaction mechanism in combustion	T2,R1	
56	Solve problems on material balance with chemical reaction and combustion Concept of recycle and by pass	T1,R1	
57	Definition of terms of Combustion	T1,T2	
58	Problem solving on combustion	R1	
59	Excess air, Problems related to combustion	R1	
60	Revision	T1,R1	

Course Delivery Plan

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
MODULE	1 & 2	2	3	3	3	3& 4	4	4	4 &5	5	5	5	5&6	6	6

BOOKS FOR REFERENCE:
TEXT BOOKS

T1: Stoichiometry by Bhatt & Vora, East TMH Publication.
T2: Chemical process principle by Hougen and Watson, CBS Publication

REFERENCE

R1: Introduction to Process Calculation by K A Gavane, Nirali Prakasan.

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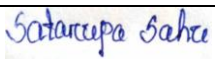
Signature		
Name	**Satarupa Sahu**	**B.K GANTAYAT**
Designation	**Lecturer**	**HOD, Chemical.**

QUESTION BANK ON INDUSTRIAL STOICHIOMETRY
3RD SEMESTER, CHEMICAL ENGINEERING
UTKALMANI GOPABANDHU INSTITUTE OF ENGINEERING, ROURKELA
PREPARED BY SATARUPA SAHU

A. 2 MARKS

1. Define unit.
2. Classify the physical quantities.
3. Define basis of calculation.
4. Define katom and kmole.
5. Write down the formula for weight fraction and mole fraction.
6. Write down the formula for weight % and mole %.
7. Define principle of atom conservation.
8. Define limiting reagent and excess reagent.
9. Define Ideal gas law.
10. Write down the formula for average molecular weight of a binary system.
11. Write down the formula for density of gas mixture involving average molecular weight.
12. Define Partial pressure and vapour pressure.
13. Define Amagat's law.
14. Define Dalton's law.
15. Define Roult's law
16. Define Henry's law.
17. State Law of conservation of mass.
18. Write overall material balance based on mixing with block diagram.
19. Write overall material balance based on Evaporation with block diagram.
20. Write overall material balance based on Distillation with block diagram.
21. Write overall material balance based on Drying with block diagram.
22. Write overall material balance based on Extraction with block diagram.
23. Write overall material balance based on Absorption with block diagram.
24. Write down the formula for percentage excess.
25. Write down the formula for conversion.
26. Write down the formula for yield.
27. Write down the formula for selectivity.
28. Define Hess's Law.
29. Define standard heat of reaction.
30. Define recycle and by pass and recycle ratio.

B. 5 MARKS

1. Write down the formula for weight fraction, mole fraction, volume %, weight % and mole % of a binary mixture.
2. Find molecular weight of (i) H_2SO_4 (ii) Na_2CO_3 and (iii) $KMnO_4$
3. Derive relationship between partial pressure and total pressure of a gas mixture.
4. Derive relationship between pure component volume and total volume of a gas mixture.
5. An aqueous solution of sodium chloride is prepared by dissolving 25 kg of sodium chloride in 100 kg of water. Determine (a) weight % and (b) mole % composition of solution.
6. 15 kg of carbon dioxide is compressed at a temperature of 303 K (30 °C) to a volume of 0.5 m3. Calculate the pressure required for given duty. Assume ideal gas law is applicable.
7. Assuming air to contain 79 % nitrogen and 21% Oxygen, by volume, calculate the density of air at NTP.

8. A solution containing 55% benzene, 28% toluene and 17% xylene by weight is in contact with its vapour at 373 K (100°C). Calculate the total pressure and molar composition of the liquid and vapour.
   Data: Vapour pressure data at 373 K (100°C).
   Benzene = 178.60 kPa, Toluene = 74.60 kPa, Xylene = 28 kPa
9. A compound having molecular weigh 60 is the following composition of the elements: C = 20%, Oxygen, = 26.66%, Nitrogen, = 46.66% and rest hydrogen. Find out the emperical formula of the compound and probable name of the compound.
10. An evaporator is fed with 15000 kg/h of a solution containing 10% NaCl ,15% NaOH and rest water. In the operation, water is evaporated and NaCl is precipitated as crystals.The thick liquor leaving the evaporator contains 45% NaOH, 2% water.
    Calculate:
    (a) kg/h water evaporated, (b) kg/h salt precipitated, (c) kg/h thick liquor.
11. The dilute acid containing 25% H_2SO_4 is concentrated by commercial grade sulfuric acid containing 98% H_2SO_4 to obtain desired acid containing 65% H_2SO_4. Find the quantities of the acids required to make 1000 kg of desired acid.
12. 2000 kg of wet solids containing 70% solids by weight are fed to a tray dryer where it is dried by hot air. The product finally obtained is found to contain 1% Moisture by weight, calculate
    (a) the kg of water removed from wet solids,
    (b) the kg of product obtained.
13. In manufacture of acetic acid by oxidation of acetaldehyde, 100 kmol of acetaldehyde is fed to a reactor per hour. The product leaving the reactor contains 14.81% acetaldehyde, 59.26% acetic acid, and rest oxygen (on mole basis). Find the percentage of conversion of acetaldehyde.
14. In manufacture of sulphur trioxide, feed to a reactor consists of 50 kmol sulphur dioxide and 150 kmol air. Calculate the % excess air is used.
15. A stream of carbon dioxide flowing at a rate of 100 kmol/min is heated from 298 K (25°C) to 383 K (110°C). Calculate the heat that must be transferred using Cp.
    Data: Cp = 21.3655+64.2841*10^3 T - 41.0506 *10^6 T^2 +9.7999* 10^9 T^3, kJ/(kmol-K)
16. Calculate the standard heat of formation of chloroform gas from its elements using Hess's law.

Data :

$$C(s) + O_2(g) \rightarrow CO_2\ (g)\ \Delta H, = -393.51\ kJ/mol$$
$$H_2(g) + 0.5\ O_2(g) \rightarrow H_2O(l)\ \Delta H, = -285.83\ kJ/mol$$
$$0.5\ H_2\ (g) + 0.5\ Cl_2\ (g) \rightarrow HCl\ (aq)\ \Delta H; = -167.57\ kJ/mol$$
$$CHCl_3\ (g) + 0.5\ O_2\ (g) + H_2O(l) \rightarrow CO_2\ (g) + 3\ HCI\ (aq)\ \Delta H = -509.95\ KJ/mol$$

C. 10 MARKS

1. Write down the overall material balance, component balance equations with block diagram for mixing, evaporation, distillation, drying, extraction, absorption.
2. Find the limiting agent in the manufacturing of ammonia from nitrogen and hydrogen for the following cases.
   I. Feed: N_2= 60 kmol, H_2= 180 kmol
   II. Feed: N_2= 60 kmol, H_2= 200 kmol
   III. Feed: N_2= 60 kmol, H_2= 150 kmol
   IV. Product: NH_3=20 kmol, N_2= 10 kmol, H_2= 20 kmol