Program Name : **Diploma in Chemical Engineering**

Program Code : **CH**

Semester : **Third**

Course Title : **Industrial Stoichiometry**

Course Code : **22315**

1. RATIONALE

Diploma chemical engineers have to deal with various material and energy balance operation; they also have to perform analysis of process data through various computation methods. Industrial Stoichiometry helps diploma chemical engineers to formulate material and energy balance equation applied in the design of different chemical processes. This course is designed by which fundamental information will help the technologists to apply the basic concepts and principles of Industrial Stoichiometry to solve broad-based engineering problems.

2. COMPETENCY

The aim of this course is to help the students to attain the following industry identified competency through various teaching learning experiences:

- **Apply unit operation and unit process in chemical industries.**

3. COURSE OUTCOMES (COs)

The theory and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Use different physical quantities and system of unit in chemical process industries.
b. Use the gas law in various chemical engineering processes.
c. Apply the law of conservation of mass in chemical process industries.
d. Calculate the amount of raw material and product for chemical process.
e. Select the fuel for combustion process in chemical process industry.
f. Apply law of conservation of energy in chemical engineering application.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme													
				Theory						Practical							
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
4	2	-	6	3	70	28	30*	00	100	40	--	--	--	--	--	--	

(*): Under the theory PA, out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs;.

***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP(sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

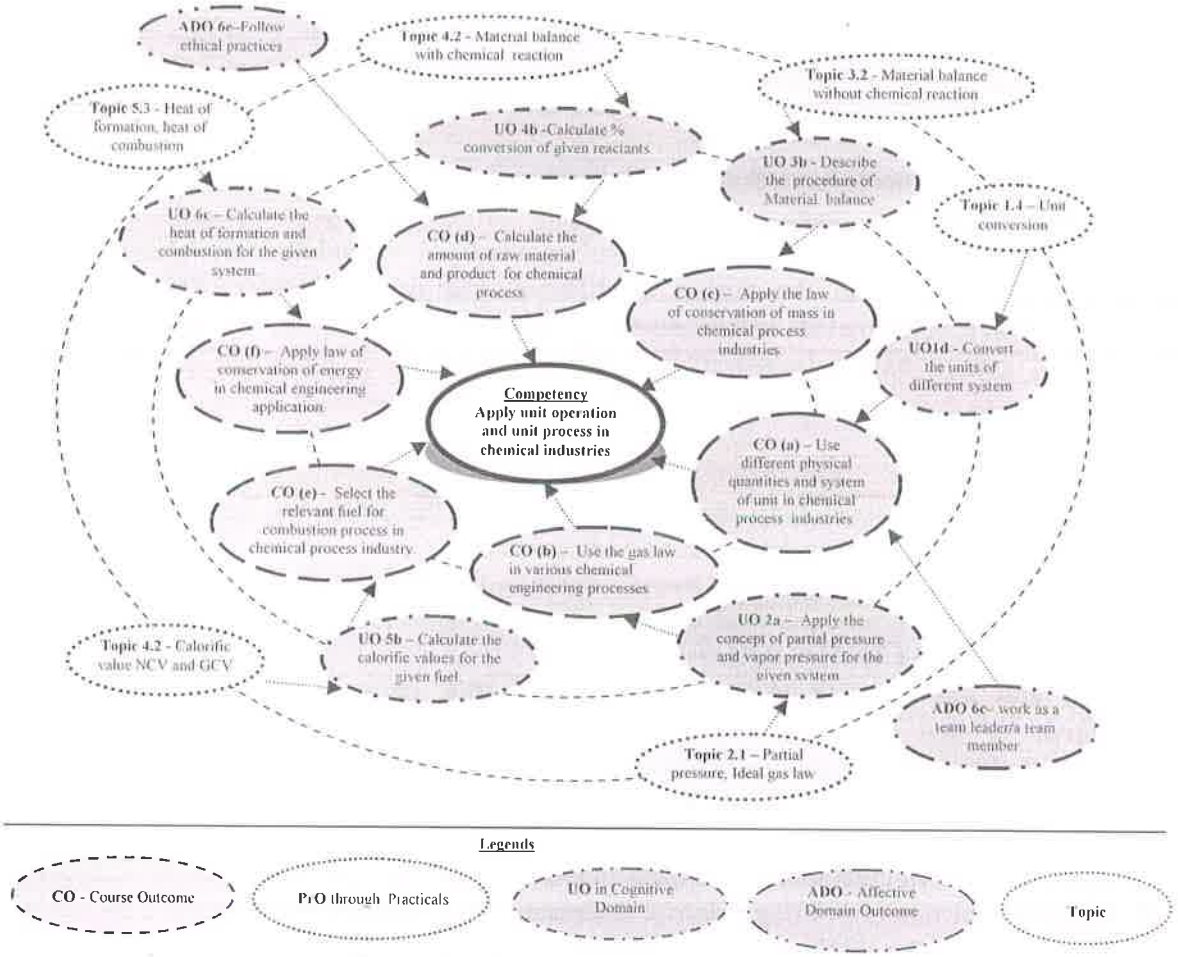

Figure 1 - Course Map

6. SUGGESTED EXERCISES/PRACTICALS/TUTORIALS

The tutorials in this section (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Tutorial	Unit No.	Approx. Hrs. Required
1	Solve numerical based on conversion of units of physical quantity among SI, MKS, CGS and FPS system	I	2
2	Solve numerical using ideal gas law and Dalton law.	II	2
3	Solve numerical using Amagat's law and Raoult's law.	II	2
4	Solve numerical on calculation of average molecular weight, average density and composition of gas in mol and wt %.	II	2
5	Solve numerical on material balance without chemical reaction at steady state condition for distillation, evaporation and drying	III	2
6	Solve numerical on material balance without chemical reaction at steady state condition for absorption and extraction.	III	2

S. No.	Tutorial	Unit No.	Approx. Hrs. Required
7	Solve numerical on material balance without chemical reaction at steady state condition for mixing, blending filtration and crystallization.	III	2
8	Solve numerical on material balance involving chemical reaction to calculate stoichiometric ratio, limiting and excess reactant.	IV	2
9	Solve numerical on calculation of % excess reactant for the given chemical reaction.	IV	2
10	Solve numerical on calculation of composition of product and reactant.	IV	2
11	Numerical on gross and net calorific value for the given fuel.	V	2
12	Numerical on requirement of air and composition of flue gases for combustion process.	V	2
13	Numerical on heat capacities calculation for pure component and mixture.	VI	2
14	Numerical on sensible heat and latent heat.	VI	2
15	Numerical on heat of formation using given data.	VI	2
16	Numerical on standard heat of reaction using heat of formation and heat of combustion data.	VI	2
Total			**32**

Note: The above tutorial sessions are for guideline only. The remaining tutorial hours are for revision and practice

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED:

- Not applicable –

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Dimensions and Units	1a. Apply the system of unit to the given physical quantities. 1b. Differentiate fundamental and derived quantities of the given system. 1c. Apply the units of different physical quantities to the given system. 1d. Convert the specified units to the given system.	1.1 Dimension and system of units 1.2 Fundamental quantities and derived quantities. 1.3 Units of force, volume, pressure, work, energy, heat and power 1.4 Units: conversion, SI, MKS, CGS and FPS system
Unit– II Law of Gases and Gas Mixtures	2a. Apply the concept of partial pressure and vapor pressure to the given system. 2b. Solve numerical based on the ideal gas law. 2c. Apply Raoult's Law to solve the given problem. 2d. Calculate the average molecular weight and density for the given chemical system.	2.1 Partial pressure, vapor pressure and pure component volume: definition 2.2 Ideal gas law, Dalton's law, Amagat law, Boyle's law and Charles law, Van der waal equation 2.3 Relation between vol%, mol% and pressure% for an ideal gas 2.4 Raoult's and Henry's Law: statement, numerical 2.5 Average molecular weight, density of gas mixture: numerical
Unit-III Material Balance Without Chemical Reactions	3a. Apply the law of conservation of mass for the given system. 3b. Describe the procedure of material balance without chemical reaction for the given chemical system. 3c. Calculate the quantity of raw materials for the given unit operation. 3d. Apply the recycle operations for the given material.	3.1 Law of conservation of mass, Steady and unsteady state operation. 3.2 Material balance without chemical reaction: Concept and procedure. 3.3 Material balance equation for unit operations: definition, block diagram, numerical based on units operations, distillation, drying, extraction, evaporation, crystallization, absorption, filtration, mixing and blending. 3.4 Recycle (Purge) and bypass operation
Unit-IV Material Balance With Chemical Reactions	4a. Apply the stoichiometric equation in identification of the given limiting and excess reactant. 4b. Calculate % conversion of the given reactants. 4c. Calculate % yield of the given product. 4d. Calculate % excess reactant for	4.1 Chemical reaction terms: stoichiometric equation, stoichiometric coefficient, stoichiometric ratio. 4.2 Material balance with chemical reaction: calculation of % conversion, %yield, % excess reactant, composition of product and reactant, numerical.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	the given chemical reaction.	
Unit-V Fuel and Combustion	5a. Select relevant fuel for the given industrial application. 5b. Calculate the calorific values for the given fuel. 5c. Describe the combustion process for the given system. 5d. Calculate the air required for combustion of given fuel.	5.1 Fuel: types of fuel (solid, liquid and gaseous fuel) 5.2 Calorific value NCV and GCV: 5.3 Combustion process: complete combustion and incomplete combustion. 5.4 Composition of flue gases, requirement of air.
Unit– VI Energy Balance	6a. Apply the law of conservation of energy for the given system. 6b. Calculate the heat involved during phase change for the given system. 6c. Apply Hess's law for the calculation of heat of formation for the given chemical system. 6d. Calculate standard heat of reaction for the given system.	6.1 Law of conservation of energy, different forms of energy. 6.2 Heat: types of heat (sensible heat and latent heat) specific heat, heat capacity 6.3 Heat of combustion, heat of formation and Hess's law of constant heat summation 6.4 Heat of reaction, Heat of dilution and dissolution.

***Note**: To attain the COs and competency, above listed Learning Outcomes (LOs) need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Dimension and Units	04	02	02	02	06
II	Laws of gases and gas mixtures	10	02	04	04	10
III	Material balance without chemical reactions	16	02	06	10	18
IV	Material balance with chemical reactions	16	02	06	10	18
V	Fuel and combustion	08	02	02	04	08
VI	Energy balance	10	02	04	04	10
Total		**64**	**12**	**24**	**34**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*

***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various

outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Use Excel formulae and function for calculation.
b. Draw block diagram and write down overall and component material balance for mechanical operations.
c. Draw block diagram and write down overall and component material balance for various mass transfer operations.
d. Prepare material data sheet for a given process.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the LOs/COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. **Preparation of chart:** Prepare a chart of molecular weight and equivalent weight.
b. **Preparation of chart:** Prepare chart on mathematical equation of different laws for gas and gas-liquid mixture.
c. **Visit of chemical process plant**: Prepare block diagram showing material balance for process equipment used in plant which you have visited.
d. **Sample Collation:** Collect the various samples of reactant and prepare the list of physical properties.
e. **Sample Collation:** Collect the samples of various fuels and prepare the relationship chart of their physical properties with temperature.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Stoichiometry	Bhatt B. I. and Vora S. M.	McGraw Hill Education., New Delhi, 2004, ISBN: 0-07-049494-0
2	Basic principle and calculations in chemical engineering	Himmelblau David M. and Riggs	Prentice Hall of India Pvt. Ltd., New York, 2012, ISBN: 01-203-1145-0
3	Chemical Process Principles	Hougen and Watson	Wiley Eastern Ltd., New Delhi, 2004, ISBN 13:9798123909539
4	Elementary Principles of Chemical Processes	Felder R.M. and Rousseau R. W.	John and Wiley Sons , New York, 1978 13:9780471873242
5	Introduction to chemical Engineering	Ghosal S. K. , Sanyal K S. and Datta Siddharth	Mc Graw Hill Publication, New York 2011, ISBN 9780074601402
6	Chemical Engineering Volume 2	Coulson and Richardson	Elsevier Publication, Oxford, 2002, ISBN 978-0-7506-4445-7

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.unitoperation.com
b. www.dplot.com/ - DPlot
c. Video lectures from NPTEL website