

# GUJARAT TECHNOLOGICAL UNIVERSITY

## CHEMICAL ENGINEERING

PROCESS CALCULATION

SUBJECT CODE: 2130504

B.E. Semester: III

**Type of course:** Fundamental Chemical Engineering Calculations & stoichiometry

**Prerequisite:** None

**Rationale:** The prime objective of this subject is to clear fundamentals of chemical engineering in a simple and forthright manner and to provide the broad background for applying these principles to industrial and theoretical problems.

After learning the course the students should be able:

- To understand the importance of stoichiometry – material and energy balances
- To deal with the laws of conservation of mass and energy
- To apply principles of unit operations and chemical reaction engineering in problem solving

### Teaching and Examination Scheme:

| Teaching Scheme |     |     | Credits<br>C | Examination Marks |    |        |                 |           | Total<br>Marks |     |
|-----------------|-----|-----|--------------|-------------------|----|--------|-----------------|-----------|----------------|-----|
| L               | T   | P   |              | Theory Marks      |    |        | Practical Marks |           |                |     |
|                 |     |     | ESE<br>(E)   | PA (M)            |    | PA (V) |                 | PA<br>(I) |                |     |
| PA              | ALA | ESE |              | OEP               |    |        |                 |           |                |     |
| 3               | 1   | 0   | 4            | 70                | 20 | 10     | 30              | 0         | 20             | 150 |

### Course Contents:

| Sr. No. | Topic   | Teaching Hrs. | Module Weightage |
|---------|---|---------------|------------------|
| 1       | <b>Dimensions and units:</b><br>Dimensions and system of units, Fundamental and derived units, Dimensional consistency, Dimensional equations, Different ways of expressing units of quantities and physical constant, Unit conversion and its significance   | 5             | 9                |
| 2       | <b>Basic chemical calculations:</b><br>Calculations for mole, molecular weight, equivalent weight, etc., Composition of gaseous mixtures, liquid mixtures, solid mixtures, etc., Ideal gas law & other equations of state and their applications, Dalton law, Raoult's law, Henry's law, Solutions and their properties   | 7             | 13               |
| 3       | <b>Material balance without chemical reactions:</b><br>Process flowsheet, Degree of freedom, Material balance with and without recycle; Bypass and purge streams, Material balance around equipments related to unit operations like absorber and stripper, distillation towers, extractors, dryers, evaporators, etc. Material balance of unsteady state operations.                           | 8             | 15               |
| 4       | <b>Material balance involving chemical reactions:</b><br>Concept of limiting and excess reactants, percentage conversion, yield, selectivity, etc., Material balance with chemical reactions - single and multiple reactions, Material balance involving reactions with special reference to fertilizers, petrochemicals, dyestuffs, electrochemical industries, metallurgical industries, etc. | 10            | 18               |
| 5       | <b>Energy balances:</b><br>Thermochemistry and 1 <sup>st</sup> law of thermodynamics, Heat capacity of gases  | 9             | 17               |

|          |  |          |           |
|----------|--|----------|-----------|
|          | and gaseous mixtures, liquids & solids, Sensible heat change in liquids & gases, Enthalpy changes during phase transformation, Enthalpy changes accompanied by chemical reactions, Standard heat of reaction, Adiabatic reactions, Thermo-chemistry of mixing processes, Dissolution of solids, etc. |          |           |
| <b>6</b> | <b>Stoichiometry and Unit operations:</b><br>Distillation, Absorption and stripping, Extraction & leaching, Crystallization, Psychrometric Operations, Drying, Evaporation etc.  | <b>7</b> | <b>13</b> |
| <b>7</b> | <b>Fuels and combustion:</b><br>Types of fuels, Calorific value of fuels, Problems on combustion of coal, liquid fuels, gaseous fuels, etc., Proximate and ultimate analysis, Combustion calculations, theoretical flame temperature, etc., Air requirement and flue gases.                          | <b>8</b> | <b>15</b> |

### Reference Books:

1. "Stoichiometry", B.I. Bhatt, S.M. Vora, McGraw Hill Publishing Company Limited, 4<sup>th</sup> edition, 2004.
2. "Basic Principles & Calculations in Chemical Engineering", David M. Himmelblau, James B. Riggs, PHI Learning Pvt. Ltd, 7<sup>th</sup> edition, 2006.
3. "Elementary Principles of Chemical Processes", Richard M. Felder, Ronald W. Rousseau, Wiley, 3<sup>rd</sup> edition, 2004.
4. "Chemical Process Principles Part-I: Material and Energy Balances", O.A.Hougen, K.M.Watson, R.A.Ragatz, CBS Publishers New Delhi, 2<sup>nd</sup> edition, 2004.
5. "Stoichiometry and Process Calculations", K.V. Narayanan, B. Lakshmikutty, Prentice-Hall of India Pvt. Ltd., 2006.
6. "Industrial Stoichiometry: Chemical Calculations of Manufacturing Processes", H.C.Lewis, W.K.Lewis, A.H.Radasch, McGraw-Hill, 2<sup>nd</sup> edition, 1954.

### Course Outcome:

After learning the course, the students should be able to:

- Establish mathematical methodologies for the computation of material balances and energy balances
- Present an overview of industrial chemical processes.
- Develop a fundamental understanding of the basic principles of chemical engineering processes and calculations.
- Examine and select pertinent data, and solve material and energy balance problems.
- Give examples of important application of material balances in chemical engineering processes.
- Evaluate their own solutions and those of others to find and correct errors.

### List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL.
- Students can refer to the CDs which are available with some reference books for the solution of problems using softwares/spreadsheets. Students can develop their own programs/ spreadsheets for the solutions of problems.

**ACTIVE LEARNING ASSIGNMENTS:** Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.