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PROCESS CALCULATIONS **Course Code : 313336**

Programme Name/s : **Chemical Engineering**
Programme Code : **CH**
Semester : **Third**
Course Title : **PROCESS CALCULATIONS**
Course Code : **313336**

I. RATIONALE

Process Calculations develops an ability in diploma chemical engineers to formulate material and energy balance equation applied in the design of chemical plants. Material and energy balance calculations play a vital role in design and conservation of mass and energy to enhance the overall economy of a chemical plant.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Compute the mass and energy balances for a certain unit operation and chemical process reactions.
Determine the quantity and composition of the input and output streams from the operation/process.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Apply the gas law for different chemical engineering operations and processes
- CO2 - Estimate requirement of materials for a unit operation using law of conservation of mass
- CO3 - Compute material balances for processes with chemical reactions
- CO4 - Calculate heat of reaction for a given chemical process
- CO5 - Calculate the calorific value of fuel to justify its quality

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
313336	PROCESS CALCULATIONS	PCL	DSC	4	2	-	-	6	3	03	30	70	100	40	50	20	-	-	-	-	150

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Apply the units of different physical quantities for the given system. TLO 1.2 Convert units among different systems TLO 1.3 Solve numerical based on the Ideal gas law TLO 1.4 Calculate vol%, mol% and pressure% for the given system TLO 1.5 Apply Raoult's and Henry's law to the given system TLO 1.6 Calculate the average molecular weight and density for the given chemical system	**Unit - I Introduction to Basic Chemical Calculations** 1.1 Various systems of units, conversion of units 1.2 Numerical on unit conversion of given system. (SI, MKS, CGS and FPS) 1.3 Partial pressure, vapor pressure & pure component volume: definition, Ideal gas law, Dalton's law, Amagat's law, Real gas equation (Van der Waal equation), reference conditions of gas: Standard Temperature & Pressure(STP), Normal Temperature & Pressure(NTP), numerical (based on Ideal gas law) 1.4 Relation between vol%, mol% and pressure% for an Ideal gas, numerical 1.5 Raoult's and Henry's Law: statement, numerical. 1.6 Average molecular weight, density of gas mixture: numerical	Lecture Using Chalk-Board Presentations
2	TLO 2.1 Apply the law of conservation of mass for the given system TLO 2.2 Delineate the procedure of material balance of process involving unit operation TLO 2.3 Write material balance equations for given unit operation TLO 2.4 Calculate the quantity of raw materials for the given unit operation at steady state condition TLO 2.5 Elaborate bypass, purge, and recycle operations used in chemical industry	**Unit - II Material Balance of Unit Operations** 2.1 Law of conservation of mass, steady & unsteady state operation 2.2 Material balance of unit operation: concept and procedure 2.3 Material balance equation for unit operations: definition, block diagram with brief description 2.4 Numerical on material balance for following unit operations at steady state condition - distillation, drying, extraction, evaporation, crystallization, absorption, filtration, mixing & blending 2.5 Recycle, purge & bypass operation: definition and applications only	Lecture Using Chalk-Board Presentations Demonstration Model Demonstration Video Demonstrations
3	TLO 3.1 Write material balance with chemical reaction TLO 3.2 Identify limiting and excess reactant for the given chemical reaction TLO 3.3 Calculate % conversion and % yield of the given system TLO 3.4 Calculate % excess reactant for the given chemical reaction	**Unit - III Material Balance with Chemical Reactions** 3.1 Chemical reaction terms: stoichiometric equation, stoichiometric coefficient, stoichiometric ratio, extent of reaction (definition) 3.2 Definition: limiting reactant and excess reactant, % excess 3.3 Simple numerical for calculating % conversion, yield and selectivity 3.4 Simple numerical for calculating % excess reactant, composition of product and reactant stream	Lecture Using Chalk-Board Presentations Model Demonstration Video Demonstrations Demonstration

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Apply the law of conservation of energy for the given system TLO 4.2 Calculate the heat involved during phase change for the given system TLO 4.3 Apply Hess's law for the calculation of heat of formation for the given chemical system TLO 4.4 Calculate standard heat of reaction for the given system	**Unit - IV Energy Balance** 4.1 Law of conservation of energy, different forms of energy, definition and unit of heat, heat capacity, specific heat, mean heat capacity of gases 4.2 Heat capacity of gas mixture and liquid mixture types of heat (sensible heat & latent heat), sensible heat changes in gases, liquids and solids, numerical on mean heat capacity 4.3 Heat of combustion, heat of formation, Hess's law of constant heat summation and numerical 4.4 Heat of reaction definition, numerical. Heat of dilution and dissolution definition	Lecture Using Chalk-Board Presentations
5	TLO 5.1 Select relevant fuel for the given industrial application TLO 5.2 Explain the combustion process for the given system TLO 5.3 Calculate the calorific values for the given fuel TLO 5.4 Calculate the air required for combustion of given fuel	**Unit - V Fuel and Combustion** 5.1 Fuel: definition, types of fuel (solid, liquid, and gaseous fuel) 5.2 Combustion process: complete combustion and incomplete combustion 5.3 Net Calorific Value (NCV) and Gross Calorific Value (GCV): definition and numerical. Constituent elements of proximate and ultimate analysis of coal 5.4 Composition of flue gases, requirement of air, numerical	Lecture Using Chalk-Board Presentations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Convert units among different systems.	1	* Numerical based on conversion of units of physical quantity among SI, MKS, CGS and FPS system.	2	CO1
LLO 2.1 Apply ideal gas law for gas and gaseous mixture	2	Numerical using ideal gas law, Dalton's law, Amagat's law and Raoult's law.	2	CO1
LLO 3.1 Use average molecular weight and estimate the density of gaseous mixture.	3	* Numerical on calculation of average molecular weight, average density, and composition of gas in mol and wt %.(Using MS Excel)	2	CO1
LLO 4.1 Use law of conservation of mass to determine material balance of given unit operation	4	* Numerical on material balance of unit operation such as distillation/ evaporation/ drying at steady state condition. (Using MS Excel)	2	CO1 CO2
LLO 5.1 Draw block diagram for given unit operation	5	Draw block diagram for distillation/ evaporation/ drying. (Using MS Office)	2	CO2
LLO 6.1 Use law of conservation of mass to calculate the quantity of raw materials for the given unit operation at steady state condition	6	* Numerical on material balance of unit operation such as mixing, blending filtration and crystallization at steady state condition	2	CO1 CO2
LLO 7.1 Use of DWSIM to determine material balance of given unit operation	7	Numerical on material balance of unit operation for distillation/ evaporation/ drying. (Using DWSIM)	2	CO1 CO2

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 8.1 Write balanced chemical reaction LLO 8.2 Identify limiting and excess reactant for given reaction system	8	* Numerical on material balance involving chemical reaction to calculate stoichiometric ratio, limiting and excess reactant	2	CO1 CO2 CO3
LLO 9.1 Calculate % excess reactant for the given chemical reaction.	9	Numerical on calculation of % excess reactant for the given chemical reaction	2	CO1 CO2 CO3
LLO 10.1 Calculate composition of product or reactant stream for a given chemical process	10	* Numerical on calculation of composition of product or reactant stream	2	CO1 CO2 CO3
LLO 11.1 Calculate mean heat capacity of gas and heat capacity of gaseous mixture	11	Numerical on calculation of heat capacities for gas and gaseous mixture	2	CO1 CO4
LLO 12.1 Apply Hess law to calculate heat of formation of a given compound	12	Numerical on heat of formation using Hess law for given data	2	CO1 CO4
LLO 13.1 Calculate heat of reaction for a given chemical process	13	* Numerical on standard heat of reaction using heat of formation and heat of combustion data	2	CO1 CO3 CO4
LLO 14.1 Enlist types of fuel used for combustion process LLO 14.2 Calculate calorific value of given fuel	14	* Numerical on gross and net calorific value for the given fuel	2	CO5
LLO 15.1 Calculate amount of air for combustion of given fuel LLO 15.2 Calculate composition of flue gases for given combustion process	15	Numerical on requirement of air and composition of flue gases for combustion process	2	CO1 CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING) : NOT APPLICABLE

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	DWSIM Software (Open Source)	7

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Basic Chemical Calculations	CO1	12	4	4	6	14
2	II	Material Balance of Unit Operations	CO1,CO2	14	2	6	10	18
3	III	Material Balance with Chemical Reactions	CO1,CO2,CO3	14	2	6	10	18
4	IV	Energy Balance	CO1,CO3,CO4	12	2	4	6	12
5	V	Fuel and Combustion	CO1,CO5	8	2	2	4	8
Grand Total				**60**	**12**	**22**	**36**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Tutorial of 50 Marks
- Two Class Test of 30 Marks

Summative Assessment (Assessment of Learning)

- End Semester Exam of 70 Marks

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	2	2	-	-	1	1			
CO2	3	3	2	2	1	1	2			
CO3	3	3	2	2	1	1	2			
CO4	3	3	2	2	1	1	2			
CO5	3	3	1	1	-	1	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	B. I. Bhatt, Shuchen B. Thakore	Stoichiometry	McGraw Hill, 2010, ISBN: 9780070681149, 0070681147
2	Himmelblau David M. and Riggs	Basic Principle and Calculations in Chemical Engineering	Prentice Hall, 2012, ISBN: 9780132346603, 0132346605
3	Hougen and Watson	Chemical Process Principles	Wiley Eastern Ltd., New Delhi, 2004, ISBN 13:9798123909539
4	S.K. Ghoshal, S.K. Sanyal, S. Datta	Introduction to Chemical Engineering	Tata McGraw Hill Education Private Limited, ISBN: 9780074601402, 0074601407
5	Felder R. M. and Rousseau R. W.	Elementary Principles of Chemical Processes	Wiley, 2020, ISBN: 9781119498636, 1119498635

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.msubbu.in/sp/pc/	Solved Numerical in Process Calculation
2	https://unacademy.com/goal/gate-ese/QGFRK/free-platform/chemical-engineering/process-calculation/LBVWG	Video Lectures
3	https://archive.nptel.ac.in/courses/103/105/103105209/	Video Lectures, Transcripts
4	https://dwsim.org/	DWSIM Open Source Software

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Sr.No	Link / Portal	Description

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

MSBTE Approval Dt. 02/07/2024 **Semester - 3, K Scheme**