Program Name : **Diploma in Chemical Engineering**

Program Code : **CH**

Semester : **Third**

Course Title : **Technology of Inorganic Chemicals**

Course Code : **22314**

1. RATIONALE

Diploma chemical engineers have to work as plant operator. During their course of work they have to deal with various aspects of manufacturing technology. It is essential for them to giving maximum output with minimum cost and pollution .This subject will provide information towards raw materials process and industrial application for manufacturing of inorganic chemicals like acids, fertilizers, cement etc. This course will provide necessary skill to perform the job role.

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 basic concepts of inorganic chemistry in chemical engineering applications.**

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. Manufacture the inorganic acids in chemical process industries.
b. Prepare Ammonia-based fertilizers in chemical process industries.
c. Select the raw material for Phosphate based fertilizer manufacturing.
d. Prepare Caustic soda in chemical process industries.
e. Synthesize the Cement of known composition.
f. Manufacture industrially important gases.

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	-	4	8	3	70	28	30*	00	100	40	50#	20	50	20	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 (with 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.

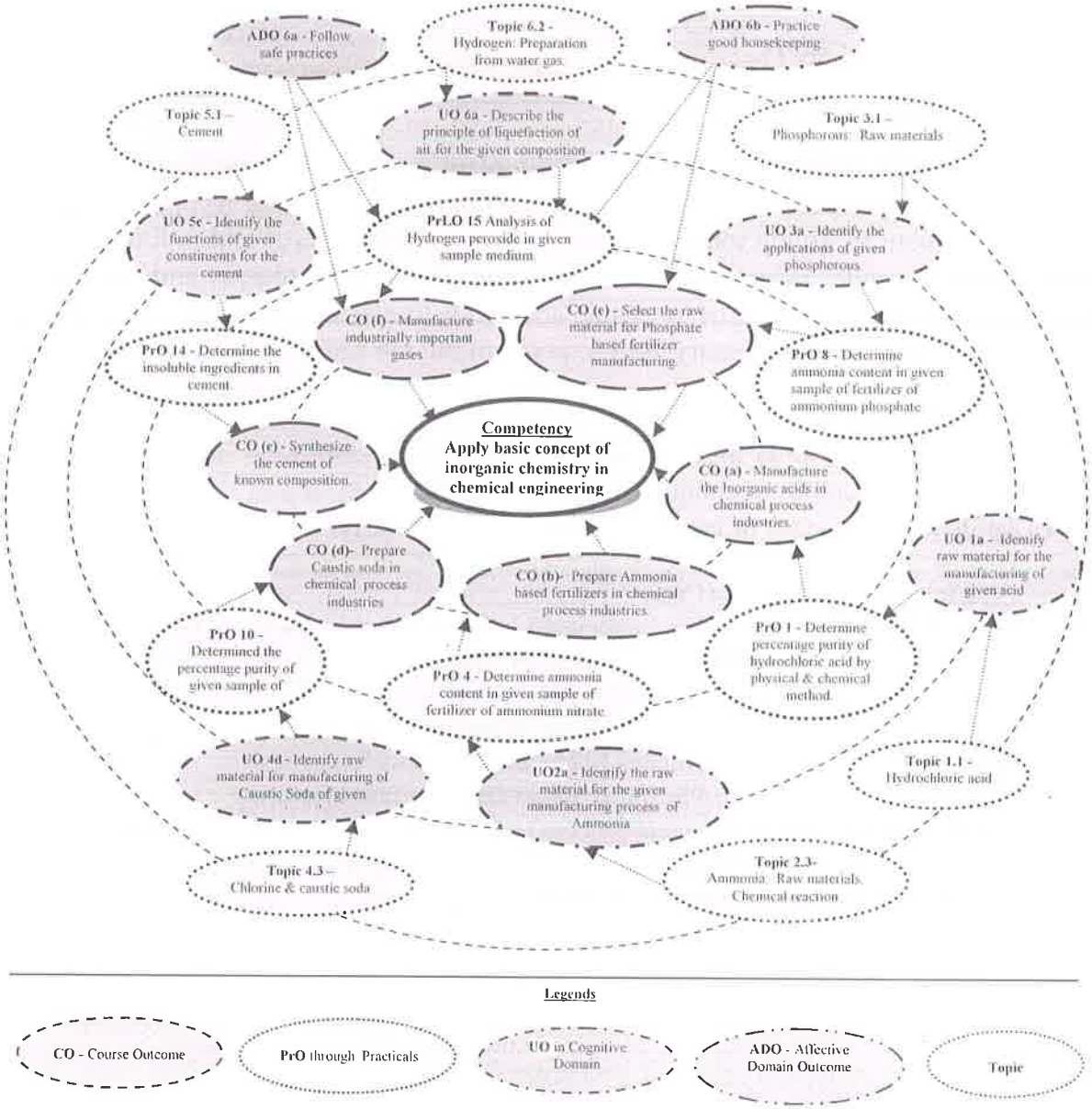

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Determine percentage purity of commercial grade hydrochloric acid by physical and chemical method.Part - I	I	02*
2	Determine percentage purity of commercial grade hydrochloric acid by physical and chemical method.Part - II	I	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
3	Determine percentage purity of commercial grade sulfuric acid by physical and chemical method. Part - I	I	02*
4	Determine percentage purity of commercial grade sulfuric acid by physical and chemical method. Part - II	I	02*
5	Determine percentage purity of commercial grade Nitric acid by physical and chemical method. Part - I	I	02*
6	Determine percentage purity of commercial grade Nitric acid by physical and chemical method. Part - II	I	02*
7	Determine the strength of given Nitric acid by pH meter. Part-I	I	02*
8	Determine the strength of given Nitric acid by pH meter. Part-II	I	02*
9	Determine the strength of given Hydrochloric acid by pH meter. Part-I	I	02*
10	Determine the strength of given Hydrochloric acid by pH meter. Part-II	I	02*
11	Determine ammonia content in given sample of fertilizer of ammonium nitrate. Part - I	II	02*
12	Determine ammonia content in given sample of fertilizer of ammonium nitrate. Part - II	II	02*
13	Determine ammonia content in given sample of fertilizer of ammonium sulphate. Part - I	II	02*
14	Determine ammonia content in given sample of fertilizer of ammonium sulphate. Part - II	II	02*
15	Determine ammonia content in given sample of fertilizer of ammonium chloride. Part - I	II	02*
16	Determine ammonia content in given sample of fertilizer of ammonium chloride. Part - II	II	02*
17	Determine nitrogen content in given sample of ammonium fertilizer. Part - I	II	02*
18	Determine nitrogen content in given sample of ammonium fertilizer. Part - II	II	02
19	Determine ammonia content in given sample of ammonium phosphate. Part - I	III	02*
20	Determine ammonia content in given sample of ammonium phosphate. Part - II	III	02
21	Determine the percentage of CaO in given sample of lime stone. Part - I	III	02*
22	Determine the percentage of CaO in given sample of lime stone. Part - II	III	02
23	Determined the percentage purity of given sample of caustic soda. Part - I	IV	02*
24	Determined the percentage purity of given sample of caustic soda. Part - II	IV	02
25	Determined percentage purity of given sample of soda ash. Part - I	IV	02*
26	Determined percentage purity of given sample of soda ash. Part - II	IV	02
27	Determine the calcium content in cement. Part - I	V	02*
28	Determine the calcium content in cement . Part - II	V	02
29	Determine the insoluble ingredients in cement. Part - I	V	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
30	Determine the insoluble ingredients in cement. Part - II	V	02
31	Determine the carbon dioxide from given sample of water. Part - I	VI	02*
32	Determine the carbon dioxide from given sample of water. Part - II	VI	02
	Total		**64**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 24 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
a.	Selection of suitable component, apparatus/instrument	20
b.	Preparation of experimental set up	10
c.	Setting and operation	10
d.	Safety measures	10
e.	Physical presence during practical	10
f.	Observation and recording	10
g.	Interpretation of result and conclusion	10
h.	Answer to sample question	10
i.	Submission of report in time	10
	Total	**100**

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
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	Pro. S. No.
1	Beakers (100ml to 500ml)	All Expt.
2	Burette with stand, 50 ml	All Expt.
3	Thermometer	01,02,03
4	Hydrometer	01,02,03,
5	Conical flask (100 to250ml.)	All Expt.
6	pipette (10 to 25ml)	All Expt.
7	Measuring cylinder (10 to 50ml)	All.Expt.
8	Weighing balance	All Expt.
9	Ceramic crucible	09
10	Laboratory oven up to temperature range of 250° C.	09
11	Bottles (250ml)	All Expt.
12	Test Tube (20ml)	All Expt.

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 Inorganic Acids	1a. Identify raw material for the manufacturing of the given acid with justification. 1b. Describe with sketches the process flow diagram for the manufacturing of the given acid. 1c. Identify the components of chemical reaction for the given acid manufacturing with justification. 1d. Describe with sketches the evaporation process for manufacturing the given acid.	1.1 Hydrochloric acid: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries. 1.2 Sulfuric acid: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries. 1.3 Nitric acid: Raw materials, Chemical reaction, manufacturing process, Process flow diagram Industrial applications, Economics, Manufacturing industries. 1.4 Phosphoric Acid: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– II Ammonia based Fertilizers.	2a. Identify the raw material for the given manufacturing process of Ammonia with justification. 2b. Describe with sketches the given manufacturing process of Ammonium Nitrate. 2c. Describe with sketches the given chemical reaction for Ammonium sulfate manufacturing. 2d. Describe with sketches the the manufacturing of given Urea derivative.	2.1 Ammonia: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries 2.2 Ammonium Nitrate: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries 2.3 Ammonium sulfate: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries 2.4 Urea: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics, Manufacturing industries
Unit– III Phosphoro us based fertilizer.	3a. Identify the applications of the given phosphorous with justification. 3b. Eliminate the hydrofluoric acid from the given chemical manufacturing process. 3c. Describe with sketches the manufacturing of the given fertiliser. 3d. Describe the conversion process for the given MAP-DAP.	3.1 Phosphorous: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics and Manufacturing industries 3.2 Super phosphate: Raw materials, Chemical reaction, Manufacturing process, Process flow diagram, Industrial applications, Economics and Manufacturing industries 3.3 Triple Superphosphate: Raw materials, Chemical reaction, manufacturing process, Process flow diagram, Industrial applications, Economics and Manufacturing industries 3.4 Di-Ammonium phosphate: Raw materials, chemical reaction, manufacturing process, process flow diagram, industrial applications, economics and manufacturing industries

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-IV Potassium based fertilizer and Chloro Alkali Material	4a. Identify the components of mixed fertilizers for the given grades. 4b. Apply the relevant chemical reaction for the given Potassium fertilizer.	4.1 Mixed fertilizer: Definition, grades, Application 4.2 Potassium fertilizer: Raw materials, Chemical reaction, Process flow diagram, Manufacturing Process, Industrial applications, Economics and manufacturing industries.
	4c. Apply electrolysis of brine for the given application. 4d. Identify raw material for manufacturing of Caustic Soda of the given strength.	4.3 Chlorine and caustic soda: Raw materials, Chemical reaction, Process flow diagram, Manufacturing Process, Industrial applications, Economics and Manufacturing industries 4.4 Soda Ash: Raw materials, Chemical reaction, Process flow diagram, Manufacturing Process, Industrial applications, Economics and Manufacturing industries
Unit V Cement and Refractories	5a. Identify the chemical composition of the given cement. 5b. Identify the functions of the given constituents for the cement. 5c. Apply the principle of setting and hardening for the given composition of cement. 5d. Identify the Refractivity for the given application.	5.1 Cement: Definition, Portland cement, classification, raw materials, chemical composition, function of constituents, setting and hardening, special cements, water proof cement, white portland cement, colored cement, plaster of paris. 5.2 Refractory: definition, types, acidic basic and neutral refractivity, composition, properties, applications.
Unit VI Industrial Gases	6a. Describe the principle of liquefaction of air for the given composition. 6b. Explain the heat economy for the given waste heat boiler. 6c. Describe the concept of absorption for the given manufacturing process. 6d. Apply the process of hydrolysis for the given system.	6.1 Oxygen and Nitrogen: Principle, Linde's and Claude's method 6.2 Hydrogen: Preparation from water gas. 6.3 Carbon dioxide: from flue gases. 6.4 Acetylene: from calcium carbide 6.5 Water gas: preparation using coal 6.6 Producer Gas: By using coal.

***Note**: To attain the COs and competency, above listed Unit Outcomes (UOs) 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	Acids	12	02	04	06	12
II	Ammonia based fertilizers	12	02	04	06	12
III	Phosphorous based fertilizer	12	02	04	06	12
IV	Potassium based fertilizer and Chloro Alkali Material	13	02	04	06	12
V	Cement and Refractory	07	02	04	04	10
VI	Industrial Gases	08	02	04	06	12
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. Identify engineering problems based on real world problems and solve with the use of free tutorials available on the internet.
b. Use software's and digital resources for related topics.

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. **Visit to fertilizer plant : Visit** nearby fertilizer plant and prepare block diagram of process, List of unit operations used, Schematic sketches of each stage of manufacturing processes and process description.
b. **Internet based assignment:** Prepare a power point presentation on a topic " List of inorganic chemicals manufacturing industries in India"
c. **Chemical Engineering aspects in cement Industry (Internet based assignment):** Identify a cement Industry, Make the list of product manufactured, make the list of unit operations and unit processes, Describe the identified unit operations and unit processes, Identify the job role for a chemical engineer in Cement industry, Safety precautions.
d. **Collection of different fertilizer sample from market. (Field assignment) :** Collect two samples from four companies. Classify the samples on the basis of content. identify the location of industry, Prepare a report based on content and cost
e. **Testing procedure of PUC:** Observe procedure of testing for four wheelers, Study pollutants present, Prepare a report for five vehicles.
f. **Profile of PSUs**: Prepare a chart demonstrating profile of typical public sector organization, RCF, IFFCO, ZUARI, containing product manufactured, block diagram, technical specification of product manufactured, safety aspects related to product, unit operations and processes involved.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Dryden's outline of Chemical Technology.	Gopal Rao, M. and Sitting, Marshal	East West Publisher, London, 2010, ISBN: 9788185938790,
2	Shreve's Chemical Process Industries.	Austin, George T.	McGraw-Hill Book Company, Tacoma, WA, U.S.A,1984 ISBN: 9780070571471
3	Unit Process of Organic synthesis.	Groggins, P.H.	Mc Graw Hill International, New York, 1958 ISBN: 8185938792
4	Reactions and Synthesis	Francis A. Carey, Ri chard J. Sundberg	Springer, Basel, 2012, ISBN: 1-4613-9798-7

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www. people.clarkson.edu
b. www.creatingtechnology.org
c. www.pafko.com/history
d. www.thechemicalengineer.com/

e. www.iisc.ernet.in
f. www.tep.engr.tu.ac.th
g. www.ichemeblog.org/
h. https://www.acs.org/chemicalsafety
i. www.chemistry.harvard.edu