Contents

Syllabus

Curriculum of the subject is divided into eleven modules and 45 lectures.

Module No.	Lecture Numbers	Topics to be covered
Module No. 1	1	**Overview**
		Introduction, classification of chemical industries, heavy and fine chemicals
Module No. 2	2 – 7	**Industrial Gases**
		Introduction, manufacture and uses of carbon dioxide, nitrogen, oxygen, hydrogen, ammonia, acetylene.
Module No. 3	8 – 15	**Sodium compounds**
		Sources, uses and preparation of sodium chloride. Manufacture, properties and uses of sodium carbonate, sodium bicarbonate sodium hydroxide and chlorine.
Module No. 4	16 – 21	**Mineral acids**
		Manufacture, properties and uses of nitric acid, sulfuric acid, hydrochloric acid, phosphorus and phosphoric acid
Module No. 5	22 – 25	**Cement Industries**
		Raw materials, manufacturing method, types of cement
Module No. 6	26 – 29	**Ceramic Industries**
		Raw materials, manufacturing methods and properties of white wares, clay products, refractories.
Module No. 7	30 – 32	**Glass Industries**
		Raw materials, manufacture of glass, types of glass
Module No. 8	33 – 37	**Phosphorus based agrochemicals**
		Introduction of fertilizers. Synthesis, properties and uses of ammonium phosphate, super phosphate, triple super phosphate.
Module No. 9	38 – 40	**Nitrogen fertilizers**
		Introduction, manufacture & properties of urea, ammonium chloride, calcium ammonium nitrate (CAN), ammonium sulfate
Module No. 10	41 - 42	**Potassium fertilizers**
		Introduction manufacture and properties of potassium chloride and potassium sulfate
Module No. 11	43 – 45	**Paint Industries**
		Introduction, types, manufacture and properties of paints

Module: 1

Lecture: 1

HEAVY AND FINE CHEMICALS

OVERVIEW

Chemical industries are basically divided into two groups.

First which produces simple compounds from the locally available large amount of raw materials usually they are very large industries and the product manufacture are purified to the extent that they can be used as raw material for other industries or they are directly marketed as a consumer goods. In general they are heavy chemical industries.

On the other hand certain industries deal with speciality chemicals and they are making small quantity of product having better quality which is sold into market as finished good. They are called as fine chemical industries.

Classification

The materials used or produced in the chemical industries are classified in the following manner.

1. **Quantity of production and consumption**

a) Heavy chemicals

Those dealt in large quantity normally crude or less purified chemicals.
E.g. mineral acid, NaOH, Na_2CO_3 etc.

b) Fine chemicals

They are complete purified substances and produced in limited quantity.
E.g. speciality solvent, perfumes, medicines etc.

2. **Chemical composition**

a) Organic compound

Compounds having carbon atom in the main structure of the molecule is called organic compound.

E.g. hydrocarbons, phenols, carboxylic acid etc.

b) Inorganic compound

They are the compounds which do not have carbon in the main structure. E.g.Na_2CO_3, $K_2Cr_2O_7$, $MgCl_2$

c) Polymers

They are the macromolecular mass compounds made from covalent bonding of repeating structured units which may be natural, synthetic or semi synthetic. E.g. polystyrene, polyvinylchloride etc.

3. Based on availability

a) Natural compounds

Compounds which are available in nature or produced or extracted from plant and animals are referred as natural products. Due to large utilization & limited production the natural source is depleting. E.g. coal, petroleum etc.

b) Synthetic products

Men made compounds are referred as synthetic products. They may be synthesized using natural product or they are synthesized completely using other type of synthetic materials, but the main target or such product is that must be suited to direct applications.

4. Based on application

a) Catalyst

A substance, usually used in small amounts relative to the reactants, that either increases or decreases the rate of a reaction without being consumed in the process. If consumed than it should regenerative at the end of process. E.g. $AlCl_3$, MnO_2, Pt etc.

b) Bulk drug

Bulk drug is the active substance used in a drug formulation. It becomes an active ingredient of a finished dosage form of the drug, but the term does not include intermediates used in the synthesis of such substances. E.g. Pantoprazole, Bisacodyl etc.

c) Resin

Resin is a natural or synthetic compound which begins in a highly viscous state and hardness with treatment.

E.g. Urea formaldehyde, epoxy, polyester etc.

d) Dyes and Pigments

A dye or a dyestuff is usually a coloured organic compound or mixture that may be used for imparting colour to a substrate such as cloth, paper, plastic or leather in a reasonably permanent fashion.

Pigments are defined as colouring agents that are practically insoluble in the application medium, whereas dyes are colouring agents that are soluble in the application medium.

Many organic pigments and dyes have the same basic chemical structure. The insolubility required in pigments can be obtained by excluding solubilizing groups, by forming insoluble salts (lake formation) of carboxylic or sulfonic acids, by metal complex formation in compounds without solubilizing groups, and particularly by incorporating groups that reduce solubility (e.g. amide groups).

e) Solvent

A liquid in which substances (or solutes) are dissolved to form a solution is called as solvent.
E.g. Benzene, THF, DMF, DMSO etc.

f) Miscellaneous

All other compounds which do not cover in above class are called as miscellaneous.
E.g. fertilizer, glass etc.

UNIT OPERATION AND UNIT PROCESS

Activities of chemical manufacturing plant are broadly covered under the label of conversion of raw materials into useful products. In some cases the product are used as starting materials for further modification and thus the product may not be termed as end product but is called as intermediate. In another cases the products are ready for marketing known as finished product. But still some of the finished products may be used for physical blending or combination with other materials and binders particularly in pharmaceutical industries.

Form the above discussion materials which are used in chemical industries can be classified into following categories.

Raw materials

They are naturally occurring material or not produced at the manufacturing unit and are procured from outside the manufacturing plant.

Intermediate

They are undergoes some processing and further proceed for modification

Finished product

Product which are ready for marketing or sale

By product

It is useful material generated with main product. Also known as co-product

Waste

Do not have any commercial value. May be discarded after giving some treatments regarding control of pollution.

Further, any commercial manufacture or production unit of chemicals have combination of series of physical and chemical changes of raw materials or intermediates or finished product. Ultimately comprehensive utilization of material for improvement in chemical properties, modification of chemicals, maximize the yield and conversion, utilization of waste products etc.

For the systematic study of chemical process industries the physical and chemical changes which are important for the manufacturing processes have been classified as unit operation and unit processes respectively

Thus,

Chemical Process Industries = Unit operation + Unit process

Unit operation

Major physical changes occur which are useful to chemical industries are known as unit operation. In majority of cases, operations are to be done to set up the condition to carry out chemical changes. Thus very important classification of various changes useful to chemical industries was needed to be done.

Unit operations shall be broadly classified as follows.

1. Fluid flow processes : Fluids transportation, filtration, solids fluidization
2. Heat transfer processes : Evaporation, condensation
3. Mass transfer processes : Gas absorption, distillation, extraction, adsorption, drying

4. Thermodynamic processes : Gas liquefaction, refrigeration
5. Mechanical processes : Solids transportation, crushing and pulverization, screening and sieving
6. Combination : Mixing
7. Separation : Distillation, extraction

Unit process

Useful chemical transformations with or without physical changes occurs in the chemical industries are called as unit process e.g. halogenations, oxidation, reduction, alkylation and acylation etc.

The study of these processes includes

- The basic knowledge of chemistry and mechanism of particular chemical reaction
- Design of equipment for the reaction
- Optimization of reaction parameter

However, still the condition and parameter for carrying unit process in plant level may differ from product to product. But the regularities emerged from the study of a particular process can be useful in setting up condition for the manufacture of new chemical which may include one or more such unit processes.

E.g. In the unit process nitration

- Reaction is almost exothermic
- Physicochemical principles of equilibrium and chemical kinetics are similar
- Material of construction of plant and equipment for the process can be predicted

The principles of widely varying sequence of making up a chemical process do not depend upon the nature of the materials being worked upon and other characteristic of the system under study. If the step of process is recognized, the process can be designed in such a way that each step to be used can be studied individually.

In both unit operations and unit processes the similarities within any unit operation or unit process are separated and studied; thus drawing attention to the like qualities of a given physical change or chemical change. Finally these results help to understanding the process, establishment of reaction parameter and reactor design. This is the scientific and engineering approach. The ultimate study by

this method of the technical changes culminated in chemical engineering formulas and laws for using the classified observations in each unit operation or unit process. These formulas and laws are the tools for the industrial chemist uses in designing or operating a chemical plant.

In conclusion, Both physical and chemical changes have been useful not only to fundamental concept but also to provide the technical detail as well as smoothen the manufacturing process at optimized reaction condition at low cost.