

**VOCATIONAL COURSE
ON
INDUSTRIAL CHEMISTRY
B. Sc. SYLLABUS**



(Effective from session 2003-2004)

**D. D. U. GORAKHPUR UNIVERSITY
GORAKHPUR**

B.Sc. I

Paper I :General Chemistry

1. **Thermodynamics and chemical equilibrium:**

Thermodynamic laws, processes and functions, free energy, partial molar quantities, activity, activity co-efficients, fugacity.
Thermodynamic criteria and equilibrium constant, effect of temperature and pressure on equilibrium constants in gaseous system (formation of ammonia).

2. **Catalysis:**

Homogeneous and heterogeneous catalysis, basic principles, mechanisms, factors affecting the performance, enzyme catalysed reactions, industrially important reactions.

3. **Periodic properties**

Electron affinity, Electronegativity and ionization potential.

4. **Basic metallurgical operations and principles of extraction:**

Pulverization, calcination, roasting, refining, principles of extraction of metals, extraction of iron and copper from their ores.

5. **Acids and bases :**

Lowery - Bronsted concept, Lewis concept, hard and soft acids and bases, Lux-Flood acids and bases.

6. **Nomenclature:**

Generic and trade names of organic compounds.

7. **Basic concepts in organic chemistry** - Homolysis and Heterolysis (carbocation, carbanion and free radicals).

field effect, electronic effects, Tautomerism, Isomerism, Elementary ideas of stereochemistry.

Paper I I: Material Science

- 1. Metals and alloys:**
Important metals and alloys - lead, nickel and their alloys- mechanical and chemical properties and their applications.
- 2. Cement:**
Types of cement, manufacture and hydration of portland cement.
- 3. Ceramics:**
Introduction, types, manufacturing processes, applications.
- 4. Polymer:** Manufacture, chemical and physical properties of Nylon 66, Bakelite, polythene, polypropylene.
- 5. Glass:**
Definition and composition, physical and chemical properties, raw materials for manufacture of glasses, manufacture of glass, special glasses - optical safety, fibre, glass wool and coloured glasses.
- 6. Corrosion:**
Various types of corrosion relevant to chemical industry- mechanism, preventive methods.
- 7. Advanced materials**
Nanomaterials, superconductors, Biomaterials and Fullerenes (only qualitative description)

Paper III: Utilities and Process in Chemical Industries

1. **Utilities in chemical industry:**
A brief idea about water, steam, air and boilers used in chemical industries
2. **Fluid flow:**
A brief idea about Fans, blowers, compressors and pumps used in chemical industries.
3. **Unit operations:**
 1. **Distillation:**
Batch and continuous distillation, Azeotropic and Extractive distillation.
 2. **Absorption:**
Equipments: Tray (Plate) towers for absorption, packed towers for absorption
 3. **Evaporation:**
Evaporator Equipments; short tube evaporator and forced circulation evaporators.
 4. **Filtration:**
Filter media and filter aids, filtration equipments- bed filters, plate and frame press filters, rotary drum filter and centrifuges.
 5. **Drying:**
Purpose of Drying, free and equilibrium Moisture of a substance, equipments- tray dryer, rotary dryer, flask dryer, fluid bed dryer, drum dryer and spray dryer.
 6. **Crystallization:**
Equilibrium Solubility, supersaturation, Definition, nucleations, crystallization, equipment- tank crystallizer, and circulating liquid evaporator crystallizer.
 7. **Extraction:**
Extraction Equipments: spray column and packed column extraction, rotating disc column extractors and mixer-settler.
 8. **Mixing:**
Mixing of Gas - Solid, solid-solid, liquid-solid and liquid - liquid systems.
 9. **Material balance:**
(a). Dimensions and units: basic chemical calculations-atomic weight, molecular weight, equivalent weight, mole, composition of (i) liquid mixtures and (ii) gaseous mixtures

4. **Material Bances :**
(i) Material balance without chemical reactions : Material balance calculations for distillation, evaporation, filtration and crystallization.
(ii) Material balance involving chemical reactions : Concepts of stoichiometric equations, limiting reactant, excess reactant, percent excess, conversion, yield and selectivity.

PRACTICALS

B.Sc. I

1. **Simple laboratory techniques:**
Crystallization, fractional crystallization, distillation, fractional distillation.
2. **Extraction process:**
Phase diagram, partition coefficient.
3. **Preparation of standard solutions:**
Primary and secondary standards, determination of H_2SO_4 and H_3PO_4 in a mixture
4. Molecular weight determination by depression in freezing point and elevation in boiling points.
5. **Chromatography:**
Column, paper, thin layer
6. **Ore analysis:**
Dolomite, lime stone, calcite, analysis of alloys such as cupro-nickel
7. **Determination of Physical constants:**
Refractive index, surface tension, viscosity of fluids and polymer solutions.
8. **Acquaintance with safety measures in a laboratory:**
Hazards and chemicals.
9. **Calibration of thermometers**

B.Sc. II

Paper I: Process Instrumentation and Industrial chemical analysis

1. **Principle, construction and working of following measuring instruments:**
 - (a) Temperature: Glass thermometers, bimetallic thermometer, pressure spring thermometer, vapour field thermometers, resistance thermometers, radiation pyrometers.
 - (b) Pressure: Manometers, barometers, Bourdon pressure gauge; bellows type, diaphragm type pressure gauges, Macleod gauges, Pirani gauges etc
 - (c) Liquid level: Direct-indirect level measurements, Float type liquid level gauge, ultrasonic level gauges; bubble system.
 - (d) Density measurement
 - (e) Viscosity measurement

2. **Industrial analysis:**

Sampling procedures, sampling of bulk materials, techniques of sampling solids, liquids and gases, collecting and processing of data.

3. **Chromatography:**

Principles, methods and applications of paper chromatography, TLC, GLC, HPLC and GPC

4. **Modern instrumental methods of analysis:**

pH and conductivity measurements with special reference to water and soil analysis, basic principles and applications of UV-visible and atomic absorption spectrometry.

Paper II: Unit processes in organic chemicals manufacture

1. **Nitration:**
Mechanism of nitration of paraffinic hydrocarbons and benzene to nitrobenzene and m-dinitrobenzene, chlorobenzene to o- and p-nitrochlorobenzene, Acetanilide to p-acetanilide, Toluene
2. **Halogenation:**
Reagents for halogenation, halogenation of aromatics- side chain and nuclear halogenations.
3. **Sulphonation:**
Introduction, sulphonating agents, chemical and physical factors on sulphonation, Mechanism of sulphonation reactions.
4. **Oxidation:**
Types of oxidation reactions, oxidizing agents, Mechanism of oxidation of naphthalene, phthalamide and anthracene.
5. **Hydrogenations:**
Thermodynamics of hydrogenation reactions, catalysts for hydrogenation reactions, hydrogenation of vegetable oils, manufacture of methanol from carbon monoxide and hydrogen.
6. **Alkylation:**
Types of alkylation, alkylating agents, thermodynamics and mechanism of alkylation reactions, manufacture of alkyl benzenes (for detergent manufacture).
7. **Esterification and Hydrolysis :**
Esterification reactions by organic acids. Commercial manufacture of ethyl acetate, vinyl acetate, cellulose acetate. hydrolysis agents, mechanism of hydrolysis.

Paper III: Inorganic Chemicals

1. Introduction to Inorganic Chemicals
2. **Industrial Gases**
N₂, O₂, H₂, CO₂ - manufacture, uses and economics
3. **Petroleum Refining Process**
Introduction, distillation, octane number, additives, hydrotreating, cracking, reforming, alkylation and polymerization, separation of natural gas (methane production).
4. **Chemicals from Methane :**
Methanol, formaldehyde, acetic acid, chlorofluoro carbons and fluorocarbons - manufacture, properties and uses.
5. **Pesticides :**
Introduction to pesticides, manufacture and use of some insecticides such as DDT, organophosphorus insecticides; herbicides such as heterocyclic nitrogen herbicides.
6. **Fertilizers :**
History and economics of fertilizers, Fertilizer materials, direct application fertilizers, mixed fertilizers (nitrogen, phosphorus and potassium sources, ammoniation) liquid vs solids, and controlled release fertilizers.
7. **Pulp and Paper Industry**
Manufacture of pulp and paper and their uses.
8. **Surfactants, Soaps and Detergents :**
Introduction, cationic and anionic surfactants, straight chain detergent intermediates linear alcohol sulphates (AS), linear alcohol ethoxy sulphates (AES) and linear alkyl benzene sulfonates (LAS), Amphoteric and detergent builders
9. **Cosmetics and Perfumes**
Definition and characteristics, creams, Hairsprays, Hairdyes, Toothpowder and tooth paste, talcum powder, face powder, lipsticks, nail polish, shampoos sun tan lotions; perfumes and essential oils.
10. **Cane Sugar Industry :**
Manufacture of white crystalline sugar, extraction of the juice, clarification (lime defaction process, by sulphate ion and by carbonation), evaporation, crystallization and refining of sugar, uses of bagasse

B.Sc. II

PRACTICALS

Unit Process: One to two examples of each

Nitration, sulphonation, Friedel-Craft reaction, esterification, hydrolysis, oxidation, halogenation, chlorosulphonation, reduction, polymerization, reactions of diazonium salts.

Instrumental methods of analysis:

Use of colourimeter, pH meter, potentiometer, conductometer, refractometer, polarimeter

Material testing:

Testing of plastics/rubber, Young's modulus, optical, thermal, mechanical and electrical properties.

Water analysis:

Solid content, hardness, COD and other tests as per industrial specifications.

Limit tests of heavy metals: Pb, As, Hg, Fe and Ash contents.

Gravimetric and volumetric estimations.

Use of transducers for measuring flow control

Flow measuring devices- floats

B.Sc. III

Paper I: Pollution, effluent treatment, waste management and industrial economics and management's.

1. Pollutants and their statutory limits, pollution evaluation methods.
2. Air pollution- various pollutants
3. Water pollution- organic/inorganic pollutants
4. Noise pollution
5. Pesticide pollution
6. Radiation pollution, green house effect
7. Sewage analysis.
8. Solid wastes- removal of solid contaminants of wastes- coagulation, sedimentation, flocculation, solid waste disposal, incineration, fuel pelletization, soil conditioning
9. Waste water treatment and its reuse in industries.
10. Gaseous wastes: Adsorption, Catalytic/non catalytic conversion, recovery of important gases, CO₂, SO₂, NO etc. Electrostatic precipitation and bag filters.
11. Factors involved in project cost estimation, methods employed for the estimation of capital investment, capital formation, elements of cost accounting, interest and investment costs, time value of money equivalence, depreciation, methods of determining depreciation, taxes, some aspects of marketing pricing policy.
12. Some aspects of marketing pricing policy, profitability criteria, economics of selecting alternatives, variation of cost with capacity, Break-even point, optimum batch sizes, production schedule etc.

POLYMERS

Paper II:

1. The science of large molecules:
Brief history, general definitions, basic chemistry and nomenclature of polymers
2. Types & general classification of polymers:
Natural, and synthetic polymers, organic & inorganic polymers, thermoplastics & thermosetting polymers, condensation and addition polymers, homo, hetero and copolymers.
3. Types of polymerization:
Addition, condensation, ionic and coordination polymerization, kinetics and mechanism of addition, condensation and ionic polymerization reactions.
4. Need of copolymers and copolymerization:
Block and graft copolymers, mechanism and kinetics of copolymerization - the copolymer equation.
5. Molecular weight and molecular weight distribution:
Number & weight average molecular weights of polymers, methods of determining molecular weights, significance of molecular weight distribution.
6. Polymer solutions:
Criteria of polymer solubility, solubility parameters, fractionation of polymers with special reference to gel permeation chromatography.
7. Polymer structure and morphology:
A brief idea of microstructure of polymers based on chemical and geometrical structures, intermolecular forces and chemical bonding in polymers, linear, branched and crosslinked polymers, stereoregular polymers, crystallinity in polymers, effect of crystallinity on the properties of the polymers, factors affecting the crystallinity.

Paper III:

1. **Plastic materials:**

[A] **Thermoplastics**

Detail study of the following thermoplastic polymers with respect to synthesis, chemistry, properties and applications.

(i) **Natural polymers:** natural rubber, cellulose, silk, gum and resin

(ii) **Commodity plastics:**

(1) Poly olefins: Polyethylenes (LDPE, HDPE), polypropylene, ethylene-propylene copolymer

(2) Styrene and styrene copolymers: Polystyrene, ABS plastics, styrene acrylonitrile (SAN)

(3) Vinyl Plastics: Polyvinylchloride, polyvinyl acetate, polyvinyl alcohol

(4) Cellulosics: Cellulose nitrate, cellulose acetate

(iii) **Engineering Plastics:**

1. UHMWHDPE & HMWHDPE

2. Polyamides: Nylon 6, 66, 610.

3. Acrylic Plastics, PMMA, PAN

4. Polyesters: Polyethylene terephthalate (PET)

5. Fluoropolymers: PTFE (Teflon)

6. Aromatic Ethers: Poly phenylene oxide

[B] **Thermoset Materials:**

Detail study of the following thermoset polymers with respect to synthesis, chemistry, properties and applications.

(i) Phenol-formaldehyde resins

(ii) Amino resins, urea-formaldehyde and melamine-formaldehyde

(iii) Polyurethanes

(iv) Epoxy resins: curing process and its importance with mechanism

(v) Unsaturated polyesters; fibre reinforced plastics (FRP) and alkyl resins.

(vi) Silicones

Paper IV

1. Rheology and mechanical properties of polymers:
Viscous flow, rubber elasticity, visco elasticity, glassy state and the glass transition temperature, (GTT) factors affecting glass transition temperature, optical, electrical and thermal properties of polymers.
2. Degradation of polymers:
Degradation of polymers by thermal, oxidative, mechanical and chemical methods, random degradation and chain depolymerization
3. Polymerization techniques:
A general idea of bulk, solution, suspension, emulsion, polymerization processes.
4. Polymer processing:
General concept of plastics, fibres and elastomers:
 - (i) Plastic Technology:
A brief idea of compression moulding, injection moulding, extrusion and blow moulding techniques, thermoforming and foaming, casting, coating and calendering, reinforcing (Fibre reinforced plastics -FRP)
 - (ii) Fibre Technology:
A brief idea of textile and fabric properties, fibre spinning (wet, dry and melt spinning),
 - (iii) Elastomer technology:
Vulcanization of elastomers, chemistry of vulcanization .
5. Additives and compounding:
A general idea of fillers, plasticizers, antioxidants, colourants, fire retardants, thermal stabilizers and compounding ingredients etc.

PRACTICALS

Testing of Polymeric Materials :

1. Preparation of representative polymers: bulk polymerization, polystyrene, PMMA Nylon and Polysulphide rubber
Solution polymerization: Phenol formaldehyde, urea formaldehyde
2. Determination of (i) acid value- gum, and resin, (ii) iodine number- linseed oil, castor oil (iii) saponification value - coconut oil, polyester (iv) Viscosity PMMA (v) Hydroxyl value of a resin
3. Determination of molecular weights of the polymers by viscosity measurements.
4. Determination of number average molecular weights of certain polymers such as polyphosphates and copolyphosphates by end group analysis method (pH. Titration)
5. Degradation kinetics of polymers, polystyrene and PMMA, Determination of T_g value of phosphate glasses.

Agrochemicals

Paper I: General & Halogenated Insecticides

Types of pest and pesticides:

Stomach poison, contact poisons systemic poisons, fumigants.

Insecticides:

Inorganic insecticides:

Arsenic insecticides, paris green, fluoro insecticides.

Insecticides of plant origin:

Nicotine, normicotine, pyrethroids, rotenoids, anabasin, aliethrin

Chlorinated hydrocarbons:

DDT, DDD, nestrin, dilan, perthan, dimite, chlorobenzilate, sulphenex, ovotran, aramite, DFDT, SAR in the class and mode of action,

BHC, chlodane, heptachlor, aldrin, dieldrin, endrin, faodrin, endosulfan, SAR in the class and mode of action.

Paper II

Organophosphorus insecticides:

Introduction, phosphoric acid derivatives- Dimecron, dichlorovos, naled, phosphinon, etc. SAR in the class.

Dithiophosphonic acid derivatives- Melathion, dimethoate, thiocron, formathion, mecarbam, etc.

Thiophosphoric acid- parathion, methyl parathion, thiophos, demetron, chlorthion, paraoxon, etc.

Pyrophosphoric acid derivatives- TEPP, sulfotepp, schradan, other organophosphorus, insecticides- Isopestox, trichlorofon, IPN.

Carbamate insecticides- Carbaryl, isolan, mesurol, zactran, demetram, pyrolan, baygon, mode of action.

Paper III: Fungicides and Herbicides

Fungicides- General introduction

Inorganic fungicides- Sulphur, lime sulphur, copper sulphate, bordeaux mixture, bordeaux paste, bordeaux paint, burgundy mixture, copper oxychloride, cuprous oxide, mercurous chloride.

Organomercuric compounds- Ethyl mercuric chloride, ceresan-M, panagen, agalol, uspulan, puratized, germisan; mode of action, agrosan GN.

Dithiocarbamates- Ziram, ferbam, thiram, nabam, zineb, maneb, captan, hinosan, vapam, etc. Mode of action.

Miscellaneous fungicides- Dithanon, diclone, captan, polpet, diflolan, mesulfan, brestan, dodine, glyodin, methirimol, terrazole.

Herbicides- Introduction: 2,4-D; 2,4-DB; 2,4-DES; MCPB; 2,4,5-I, Monujron, fenuron, TCA, paraquat.

Fumigants- HCN, CS₂, ethylene halides, durofume, methyl halides.

Rodenticides- Zinc phosphide, warfarin

Nematicides- DD mixture, aldicarb, fensulfothion

Plant growth regulators- Introduction, gibberilic acids, indole acetic and butyric acids, Naphthalene acetic acid, cycocil, mode of action.

Formulation of pesticides- Dry formulations- Dusts, granules, wettable powders, seed disinfectants, liquid formulations- emulsions, suspensions, etc., aerosols and sprays

PRACTICALS

Isolation of nicotine from tobacco leaves/ wastes

Preparation of copper sulphate, estimation of copper in copper sulphate formulations, formulations of copper sulphate, Estimation of arsenic insecticides.

Isolation and estimation of active ingredients of commercially available insecticide formulations.

Preparation of selected pesticide formulations in the form of dusts, emulsions, sprays.

Estimation of pesticide residues in food articles.

Study of the degradation of pesticides in soil in the presence of sunlight and moisture. Determination of pesticide contents in the soil.

Effect of plant growth regulators on the development of plants and fruits.

Industrial visits to agrochemical industry and submission of reports.

Pharmaceuticals

Paper I

Historical background and development of pharmaceutical industry in India in brief.

Pharmacopoeias- development of Indian Pharmacopoeia and introduction to B.P., U.S.P., E.P., N.F. and other important pharmacopoeias.

Introduction to various types of formulations and routes of administration.

Aseptic conditions, need for sterilisation, various methods of sterilisation.

Various types of pharmaceutical excipients their chemistry process of manufacture and quality, specifications- glidants lubricants, diluents preservatives, antioxidants, emulsifying agents, coating agents, binders, colouring agents, flavouring agents gelatin and other additives, sorbitol, mannitol, viscosity builders, etc.

Surgical dressing, sutures, ligatures- with respect to the process, equipments used for manufacture, methods of sterilization and quality control.

Pharmaceutical packaging materials, ancillary materials, packaging machinery, quality control of packaging materials.

Paper II

EDA, important schedules and some legal aspects of drugs.

Phytochemicals- introduction to plant classification and crude drugs, cultivation, collection, preparation for the market and storage of medicinal plants.

Evaluation of crude drugs- moisture content, extractive value, volatile oil content, foreign organic matter quantitative microscopic exercises, including of starch, leaf content (palisade ratio, stomatal number and index vein islet number and vein termination number) crude fibre content. Introduction of chromatographic method of identification of crude drugs.

Chemical constitution of plants- including carbohydrates, amino acids, proteins, fats, waxes, volatile oils, terpenoids, steriods, saponins, flavonoids, tannins, glycosides, alkaloids

Various isolation procedures for active ingredients with example for alkaloid, e.g., vincaalkaloids, reserpine; one for steriods- sapogenin, diosgenin, diagroh.

Pharmaceutical quality control (other than the analytical methods covered under core subject) - sterility testing, pyrogenic testing, glass testing, bulk density of powders, etc.

Paper III

Classification of various types of drugs with example:

Raw materials, process of manufacture, effluent handling etc., of the following bulk drugs

- (i) Sulpha drugs- sulphaguadine, sulphamethoxazole
- (ii) Antimicrobial- chloraamphenicol, furazolidine, mercurochrome, isoniazid, Na-PAS
- (iii) Antalgesic- anti inflammatory- salicylic acid and its derivatives, Iuprofen, mefenamic acid.
- (iv) Steroid hormones- progesterone, testosterone, methyl testosterone
- (v) Vitamins- Vit. A, Vit. B6, Vit. C
- (vi) Barbiturates-pentobarbital
- (vii) Blockers- propranolol, atenolol
- (viii) Cardiocascular agent- methyl dopa
- (ix) Antihistamines- chloropheneramine maleate.

Products based on fermentation processes-

Brief idea of micro-organisms, their structure, growth and usefulness, enzyme systems useful for transformation microbial products.

General principle of fermentation processes and product processing.

Manufacture of antibiotics- Pencillin- G and semisynthetic penicillins, rifamycin, tetracyclins, Vit. B12

Biotransformation processes- for prednisolone, 11- hydroxylation in steroids.

Enzyme catalysed transformation, manufacture of ephedrine.

PRACTICALS

1. Demonstration of various pharmaceutical packaging materials, quality control tests of some materials- aluminium strips, cartons, glass bottles.
2. Limit tests for chlorine, heavy metals, arsenic, etc., of two representative bulk drugs.
3. Demonstration of various pharmaceutical products.

Active ingredient analysis of few types of formulations representing different methods of analysis- acidmetry, alkametry, nonaqueous complexometry, potentiometry, etc.

Determination of sulphate ash, loss of drying, and other tests of bulk drugs, complete I.P. monograph of three drugs representing variety of testing methods.

Evaluation of crude drugs- microscopic examination- determination and identification of starch granules, calcium oxalate.

Palisate ratio, stomatal index determination and identification of few drugs. TLC methods for identification.

Microbiological testing- Determination of MIC of some antibacterial drugs by zone/cup plate methods.

Ordinance for Vocational Course on Industrial Chemistry framed in the meeting of Board of studies in Chemistry held on 28-5-99

1. Industrial Chemistry Course at B.Sc. level will run under the department of Chemistry from July 1999
2. Students who have offered Physics, Chemistry and Mathematics at the Intermediate level can offer Industrial Chemistry as one of the subjects at B.Sc. level.
3. The break up of marks will be as under

B.Sc.-I

Paper I- 45
Paper II- 45
Paper III- 45
Practical- 65

B.Sc.-II

Paper I- 45
Paper II- 45
Paper III- 45
Practical- 65

B.Sc.-III

Paper I- 50
Paper II- 50
Paper III- 50
Paper IV- 50
Practical- 65
Summer Training - 25
Industrial Tour - 10

Other conditions of the course will remain the same as for other subjects.