

Syllabus for B.Sc. I, II, III

Subject: Industrial Chemistry

B.Sc. First Year Industrial Chemistry

| Paper | Title of Paper | M.M. |
|--------------|---|-------------|
| Paper I - | Industrial Aspects of Organic and Inorganic chemistry. | 33 |
| Paper II - | Industrial Aspects of Physical chemistry, Material and Energy balances. | 33 |
| Paper III – | Unit operations, Utilities, Fluid Flow and Heat Transport in Chemical Industry. | 34 |
| Paper IV – | Practical. | 50 |

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| Paper I – | Material science and Industrial Pollution. | 33 |
| Paper II – | Unit Processes in Organic Chemicals Manufacture. | 33 |
| Paper III - | Effluent treatment, Waste management and Process instrumentation. | 34 |
| Paper IV – | Practical. | 50 |

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COMPULSORY PAPERS

| | | |
|------------|--|----|
| Paper I – | Industrial Chemical Analysis. | 40 |
| Paper IV – | Chemical Process Economics and Entrepreneurship. | 30 |
| Paper V – | Practical**. | 75 |

SELECTIVE/OPTIONAL PAPERS*

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|-----------------------------|----|
| 1. Polymers | 40 |
| 2. Pharmaceuticals | 40 |
| 3. Heavy and Fine Chemicals | 40 |

NOTES: -

- (i) *Select any **TWO** papers out of three. These two papers will be IInd and IIIrd paper respectively.
- (ii) ** The Factory visit of students of B.Sc. IIIrd Year is not compulsory for practical examination.

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Paper I - Industrial Aspects of Organic and Inorganic chemistry.

1. **Nomenclature:** Generic names, Trade names
2. **Raw materials for organic compounds:** Petroleum, Natural gas, Fractionation of crude oil, cracking, reforming, hydro forming and Isomerisation.
3. **Coal:** Types of coal, properties, calorific value, distillation of coal, chemicals derived from them.
4. **Renewable Natural resources:** Cellulose, Starch: - properties, modification, important industrial chemicals derived from them. Alcohols, oxalic acid and Furfural.
5. **Basic Metallurgical operations:** pulverization, calcinations, roasting, refining of metals.
6. **Physicochemical principles of Extraction of:** Iron, Copper, Lead, Silver, Sodium, Aluminium and Zinc.
7. **Inorganic Materials of Industrial Importance:** Availability, forms, structure and modifications of – alumina, silicates, clays, mica, carbon, zeolites.

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Paper II - Industrial Aspects of Physical Chemistry and Material & Energy balances.

1. **Surface chemistry and Interfacial phenomena:** Adsorption isotherm, Sols, Gels, Emulsions, Micro emulsions, Micelles, Aerosols, Effect of surfactants, Hydrotropes.
2. **Catalysis:** Introduction, Types, Basic principles, mechanisms, factors affecting the performance, introduction to phase transfer catalysis, Enzymes catalyzed reactions- rate model, industrially important reactions.
3. **Dimensions and Units:** Basic chemical calculations – atomic weight, molecular weight, equivalent weight, Mole concept, composition of liquid and gaseous mixtures.
4. **Material Balance without chemical reactions:** Flow diagram for material balance, simple material balance with or without recycle or bypass for chemical engineering operations such as distillation, absorption, crystallization, evaporation, extraction etc.
5. **Material Balance involving chemical reactions:** concept of limiting reactant, conversion, yield, selectivity, and liquid phase reaction, gas phase reaction with or without recycle or bypass.
6. **Energy Balance:** Heat capacity of pure gases and gaseous mixtures at constant pressures, sensible heat changes in liquids, Enthalpy changes.

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Paper III – Unit operations, Utilities, Fluid Flow and Heat Transport in Chemical Industry.

- 1. Distillation:** Introduction, batch and continuous distillation, separation of azeotropes, plate columns and packed columns.
- 2. Absorption:** Introduction, equipments, packed columns, spray columns, bubble columns, mechanically agitated contactors.
- 3. Evaporation:** Introduction, equipments, short tube evaporator, forced circulation evaporators, falling film evaporators, wiped (agitated) film evaporators.
- 4. Filtration:** Introduction, equipments, plate and frame filter press, Nutch filter, rotary drum filter, sparkler filter, candle filter, Bag filter.
- 5. Drying:** Introduction, free moisture, bound moisture, drying curve, equipments - tray dryer, rotary dryer, flash dryer, fluid bed dryer, drum dryer, spray dryer.
- 6. Utilities in Industry:**

Fuel: Types of fuels – advantages and disadvantages.

Boilers: Types of boilers and their functioning.

Water: Specifications for Industrial use, various water treatments.

Steam: Generation and use.

Air: Specifications for Industrial use, processing of air.

- 7. Fluid Flow:** Fans, Blowers, Compressors, vacuum pumps, Ejectors.

Pumps: Reciprocating pumps, Gear pumps, Centrifugal pumps.

- 8. Heat Transfer:** Heat exchangers- shell and tube type, finned tube heat exchangers, plate heat exchangers, refrigeration cycles.

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Practical:

1. Preparation of standard solution of $K_2Cr_2O_7$. To find out the concentration of unknown $K_2Cr_2O_7$ solution using $Na_2S_2O_3$ solution as an intermediate.
2. Preparation of standard solution of copper sulphate. To find out the concentration of unknown copper sulphate solution using $Na_2S_2O_3$ solution as an intermediate.
3. Preparation of standard $KMnO_4$ and ferrous ammonium sulphate solution. To find out the strength of unknown ferrous ammonium sulphate solution using as an intermediate.
4. Viscosity of liquids:
Determination of relative viscosity of a liquid with water.
Determination of % composition of an unknown solution.
5. Surface Tension of liquids:
Determination of the surface tension of an organic liquid.
Determination of % composition of an unknown mixture.
6. Polari-meter:
Determination of the specific rotation of sucrose solution.
7. Refractometer:
Determination of Refractive Index of a liquid by Abbe's refractometer.
Determination of Molar refractivity and specific refractivity of a liquid by using Abbe's refractometer.
8. To find out the melting points of organic compounds.
9. To find out the boiling points of organic compounds.
10. To find out the partition coefficient of –
Iodine between CCl_4 and water
Acetic acid between water and benzene.
11. Chromatography:
To separate and identify the amino acids by ascending paper chromatography.
To separate and identify the sugars by ascending paper chromatography.
12. Separation of a mixture of dyes by column chromatography.
13. Preparation of Aspirin.

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Paper I – Material Science and Industrial Pollution.

1. **Mechanical properties** of materials and change with respect to temperature.
2. **Metals and alloys:** Important metals and Alloys, Iron, Copper, Aluminium, Lead, Nickel, Titanium and their alloys – mechanical and chemical properties and their applications.
3. **Cement:** Types of cement, composition, manufacturing process, setting of cement.
4. **Ceramics:** Introduction, types, manufacturing processes, applications, Refractory.
5. **Polymeric Materials:** Industrial polymers and composite materials – their constitutions, chemical and physical properties, Industrial applications.
6. **Glass:** Types, composition, manufacture, physical and chemical properties, applications.
7. **Corrosion:** various types of corrosion relevant to chemical industry - mechanism, preventive methods.
8. **Industrial pollution:**
Pollutants and their statutory limits, pollution evaluation methods.
Air pollution – various pollutants
Water pollution – organic/inorganic pollutants
Noise pollution
Pesticide pollution
Radiation pollution and Green House Effect.

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Paper II – Unit Processes in Organic Chemicals Manufacture.

1. **Nitration:** Introduction, nitrating agents, mechanism and nitration of paraffin hydrocarbons - benzene to nitrobenzene, m-dinitrobenzene, chlorobenzene to o & p-nitrochlorobenzenes. Acetanilide to p-nitro acetanilide, toluene, continuous Vs batch nitration.
2. **Halogenation:** Introduction, reagents for halogenations, halogenations of aromatics – side chain and nuclear halogenations, commercial manufacture of chlorobenzene, chloral, monochloroacetic acid and chloromethanes.
3. **Sulphonation:** Introduction, sulphonating agents, chemical and physical factors in sulphonation, mechanism of sulphonation, commercial sulphonation of benzene, naphthalene, alkyl benzene, batch Vs continuous sulphonation.
4. **Oxidation:** Introduction, types of oxidation reactions, oxidizing agents, mechanism of oxidation, liquid phase oxidation and vapour phase oxidation, commercial manufacture of benzoic acid, maleic anhydride, phthalic anhydride, acetaldehyde, acetic acid.

5. **Hydrogenation:** Introduction, catalysts for hydrogenation reactions, hydrogenation of vegetable oil, manufacture of methanol from carbon monoxide and hydrogen, catalytic reforming.
6. **Alkylation:** Introduction, types of alkylation, alkylating agents, mechanism of alkylation reactions, manufacture of phenyl ethyl alcohol and ethyl benzene.
7. **Esterification:** Introduction, esterification by organic acids, by addition of unsaturated compounds, esterification of carboxy acid derivatives, commercial manufacture of ethyl acetate, vinyl acetate and cellulose acetate.
8. **Amination:**
By reduction: Introduction, methods of reduction, metal and acid, catalytic sulfide, electrolytic, metal and alkali sulfites, metal hydrides, sodium metal, conc. Caustic oxidation-reduction. Commercial manufacture of aniline, m-nitroaniline, p-aminophenol.
By aminolysis: Introduction, aminating agents, factors affecting.
9. **Hydrolysis:** Introduction, hydrolyzing agents, mechanism of hydrolysis.

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Paper III - Effluent treatment & Waste management and Process Instrumentation.

1. Principles and equipments for aerobic, anaerobic treatment, adsorption, filtration, sedimentation.
 Bag filters, Electrostatic precipitator, Mist eliminator, Wet scrubbers, Absorbers.
2. Solid waste management, Industrial safety.
Principles, construction and working of following measuring instruments –
3. **pH** meter, conductivity meter.
4. **Temperature** – Glass thermometers, bimetallic thermometer, pressure spring thermometer, vapour filled thermometer, resistance thermometers, and radiation pyrometers.
5. **Pressure** – Manometers, barometers, bourdon pressure gauge, bellow type, diaphragm type pressure gauge, Macleod gauges, pirani gauges etc.
6. **Liquid Level** – Direct-Indirect liquid level, measurement, float type liquid level gauge, ultrasonic level gauges, bubbler system.
7. **Viscosity and Density** measurement.

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Practical:

1. Determination of flash point, ignition point of liquids.
2. Determination of smoke point of a fuel.
3. Water analysis – Solid content, hardness, COD and other tests as per industrial specifications.
4. Separation of organic and inorganic mixture by TLC.
5. Instrumental methods of analysis – pH meter and conductivity meter.
6. **Unit process** – one or two examples of each of the following unit processes.
Nitration, sulphonation, Friedel Crafts reaction, esterification, hydrolysis, oxidation, halogenations, chlorosulphonation, reduction and polymerization.
7. Limit tests for heavy metals – Pb, As, Hg, Fe and ash content.

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COMPULSORY PAPERS

Paper I – Industrial Chemical Analysis.

1. **Sampling** procedures, sampling of bulk materials, techniques of sampling – solids, liquids and gases. Collection and processing of data.
2. **Chromatography:** Principles, working and applications of – paper chromatography, TLC, GLC, HPLC.
3. Particle size determination, rheological properties of liquids, plastics and their analysis.
4. **Modern Instrumental Methods of analysis –**
UV-visible spectroscopy
IR spectroscopy and non-dispersive IR
Raman spectroscopy,
NMR Spectroscopy,
Electron spin resonance spectroscopy
Atomic absorption spectroscopy
Flame photometry
Neutron diffraction
X-ray fluorescence
Ion chromatography

Paper IV – Chemical Process Economics and Entrepreneurship.

1. 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.
2. Depreciation, methods of determining depreciation. Some aspects of marketing, pricing policy, profitability criteria, economics of selecting alternatives, variation of cost with capacity, break-even point, optimum batch sizes, production scheduling etc.
3. Need, scope and characteristics of entrepreneurship, special schemes for technical entrepreneurs development (STED), exposure to demand based, resource based, service based. Import substitute and export promotion industries, criteria for principles of products selection and developments.
4. Choice of technology: plant and equipments. Techno-economic feasibility of the projects. Plant layout and process planning for the project.
5. Financial Institutions, their procedure and incentives, financial ratio and their significance. Books of accounts, financial statements and Funds flow analysis. Energy requirement and utilization.
6. Resources management: men, machine and materials. Creativity and Innovations. Problem solving approach. Strength, weakness, opportunity and threat (SWOT) techniques.
7. Quality control, quality assurance and testing of the product. Packaging and advertising. After sales service.
8. Sickness in small scale Industries and their remedial measures. Licensing and registration. Important provisions of Factory Act, sales of goods Act, partnership Act.

Practical:**

1. Synthesis of common industrial compounds involving two step reactions, e.g. 4-bromo aniline, 3-nitroaniline, sulphanilamide, 4-amino benzoic acid, 4-nitro benzoic acid, dihalobenzenes, nitrohalobenzenes, paracetamol, oils of winter green.
2. Determination of acid value, Iodine value and saponification value.
3. Instrumental methods of analysis – colorimeter, flame photometer.
4. Preparation of urea formaldehyde resin.
5. **Industrial analysis** – analysis of common raw materials as per the industrial specifications such as phenol, aniline, formaldehyde, hydrogen peroxide, acetone, etc.
6. Limit tests for chlorine, heavy metals, arsenic of drugs.
7. Determination of sulphate ash, loss on drying of drugs.
8. Identification of drugs by TLC.

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OPTIONAL PAPERS*

Paper 1: Polymers.

1. Brief history of macromolecular science, general characteristics of polymers in comparison with common organic compounds. Types of polymers - functionality concept, necessity of copolymers and copolymerization, block and graft copolymers. Conducting Polymers. Biopolymers.
2. **Methods of polymerization** – bulk, suspension, emulsion and solution.
3. **Types of polymerizations** – addition, condensation, mechanism of polymerization – free radical, ionic (anionic and cationic), co-ordination polymerization, initiators, inhibitors.
4. **Synthesis, chemistry, properties and applications of the following Thermosetting polymers:-**
Phenol-formaldehyde, urea-formaldehyde, melamine-formaldehyde, Polyurethanes, Polycarbonates, Epoxy resins – grades and curing process, Silicones.
Elastomers – polyisoprene, polybutadiene and neoprene.
5. **Synthesis, chemistry, properties and applications of the following Thermoplastics polymers:-**
Polyethylene – HDP, LDP, LLDP. Polyvinyl chloride, Teflon.
Polystyrene – SBR, ABS, SAN.
Vinyl polymers – PVA, PVB.
Polyacetals, Polyamides – nylon-6, nylon-66
Polyethers and Polyesters – terephthalates. Cellulosic polymers.
6. **Molecular weight distribution** – number, weight and viscosity average molecular weights of polymers, methods of determining molecular weights.
7. **Degradation** of polymers by thermal, oxidative, mechanical and chemical methods.
8. **Polymer processing** – compression molding, casting, extrusion, fibre spinning, injection molding, thermoforming, vulcanization of elastomers, polymer industry in India.

Paper 2: Heavy and Fine chemicals.

1. **Heavy Inorganic Chemicals** –
Manufacture of following with reference to –
 - (i) Raw material,
 - (ii) production process,
 - (iii) quality control,

- (iv) hazards and safety,
- (v) Effluent management.

Ammonium phosphates, super phosphate, triple super phosphate, carbon blacks, manufacture of graphite and carbon, calcium carbide, silicon carbide, sodium thiosulphate, borax and boric acid.

Industrial catalysts – raney nickel, other forms of nickel, palladium and supported palladium, copper chromate, vanadium and platinum based catalyst. Aluminium alkoxides, titanium tetrachloride and titanium dioxide.

2. Fine Chemicals –

Manufacture of following with reference to –

- (i) Raw material,
- (ii) production process,
- (iii) quality control,
- (iv) hazards and safety,
- (v) Effluent management.

Sodium borohydrate, lithium aluminium hydride, sodium ethoxide, paracetamol, indigo, vat dyes. Essential oils, surfactants and emulsifying agents, coloring agents- manufacture of some natural and synthetic colors. Flavouring agents – fragrance and food additives. Biochemical reagents – ninhydrin, tetrazolium blue, 1,2-naphthaquinone-4-sulphonate.

3. Heavy Organic Chemicals –

Manufacture of following with reference to –

- (i) Raw material,
- (ii) Flow chart,
- (iii) Effluent management.
- (iv) Uses.

Fischer-tropsch synthesis. Applications and uses of zeolites as catalyst. Propargyl alcohol, 1,4-butanediol, vinyl chloride, pyridines, picolines, phthalic anhydrides, glycerol, sorbitol, chloroform, ethanolamine. Industrial solvents – DMF, DMSO, sulpholane, alkyl pyrrolidone, THF, dioxane.

Paper 3: Pharmaceuticals.

1. Historical background and development of pharmaceutical industry in India. Introduction to pharmacopoeias. Types of formulations and routes of administration. Aseptic conditions, need for sterilization, Method of sterilization.

2. **Various types of pharmaceutical excipients** – their chemistry, process of manufacture and quality specifications – Glidants, lubricants, diluents, preservatives, antioxidants, emulsifying agents, coating agents, binders, coloring agents, flavouring agents, gelatin and other additives, sorbitol, mannitol, viscosity builders etc.
3. **Evaluation of crude drugs** – moisture contents, extractive value, volatile oil content, foreign organic matter. Quantitative microscopic exercises including of starch, crude fiber content. Various isolation procedures for active ingredients.
4. **Chemical constitution of plants** – including carbohydrates, amino acids, proteins, fats, waxes, volatile oils, terpenoids, steroids, saponins, flavonoids, tannins, glycosides, alkaloids.
5. **Pharmaceutical Quality Control** – sterility testing, pyrogenic testing, glass testing, bulk density of powders etc.
6. **Raw materials, process of manufacture of the following bulk drugs –**
 - Sulpha drugs – sulphaguanidine, sulphamethoxazole
 - Antimicrobial – chloramphenicol, Na-PAS.
 - Analgesic-anti-inflammatory – salicylic acid and its derivatives, ibuprofen, mefenamic acid.
 - Steroidal hormones – Progesterone, Testosterone, Methyl Testosterone.
 - Vitamins – vitamin-A, vitamin-B6, vitamin-C.
 - Blockers – propranolol, atenolol.
 - Cardiovascular agent – methyl dopa.
 - Antihistamines – chlorpheniramine maleate.
 - Antibiotics drugs – penicillin-G, semi synthetic penicillin, rifamycin, tetracycline, and vitamin-B12.
 - Antimalarial drugs. Anticancerous drugs. AntiAIDS vaccines.
7. **Brief idea of microorganisms** - their structure, growth and usefulness. Biotransformation processes – for prednisolone, 11-hydroxylation in steroids. **Enzyme systems** - useful for transformation, microbial products, enzyme catalyzed transformation - manufacture of ephedrine.