

Chemical Engineering

Compulsory Subjects

- IC 402 Engineering Management
- CH 403 Chemical Reaction Engineering
- CH 404 Transport Phenomena
- CH 405 Chemical Engineering Thermodynamics
- CH 406 Chemical Process Principles
- CH 407 Chemical Engineering Equipment Design

Optional Subjects (*Any three from any one Group*)

Group I Transfer Process

- CH 411 Mass Transfer Operations
- CH 412 Heat Transfer Operations
- CH 413 Mechanical Operations
- CH 414 Fluid Mechanics
- CH 415 Instrumentation and Control

Group II Process Technology

- CH 421 Fuels and Combustion
- CH 422 Biochemical Engineering
- CH 423 Mechanical Operations
- CH 424 Chemical Process Technology
- CH 425 Instrumentation and Control

Group III Process Industries

- CH 431 Polymer Materials and Technology
- CH 432 Petrochemical Engineering
- CH 433 Industrial Pollution and Control
- CH 434 Fertilizer Technology
- CH 435 Instrumentation and Control

ENGINEERING MANAGEMENT

Group A

Management and Organisations

Management process: Definition, planning organizing, directing, controlling, coordinating, types of management.

Organisation Definition, planning, design and development, types of organizations.

Management planning and control: Classical, new classical and modern principles.

General Management, scientific management, engineering, management, systems management.

Planning: Procedures, resources and constraints, objectives, goals, policies and procedures.

Control: Setting of reference or standards, appraisal or evaluation, monitoring and controlling, types of control.

Human resource planning and management, selection, recruitment, training, retraining, skill development, competence development, promotion and career development, participative management, trade unions, and collective bargaining,

Management of Physical Resources

Plant: site selection procedures, factors affecting selection. Layout-types and relative merits and demerits, Maintenance-Objectives, different types of associated decisions, strategies for effective maintenance, computer applications.

Material : Functions, objectives, planning and control including inventory models with or without storage costs, price break (excluding dynamic and probabilistic considerations).

Different classes of inventory. Material Requirement Planning (MRP).

Group B

Financial management: Introduction to standard forms of financial statements, i.e., balancesheet, profit and loss, and income statement. Fixed and current asset items. Fixed and current liability items. Linkage of two successive balance-sheets through income or profit and loss statement. Funds flow statement. Financial ratios and their implications.

Managerial economics: Concepts, theory of production, marginal productivity and cost. Introduction to theory of firm.

Quality management: Quality definition, quality planning, quality control and quality management, Total quality management, ISO 9000 systems, simple quality control techniques like control charts and acceptance sampling.

Marketing management consumer behavior, market research, product design and development pricing and promotion.

Project management: Introduction. Concept of a project, project management concepts, project simulation, cost or project and means of financing, economic evaluation criteria of the project, project implementation, project planning, scheduling and monitoring, project control (PERT, CPM techniques including crashing). Project evaluation.

Information technology and management. Role of information, management information system and decision support system, Information technology-introduction to e-business, ecommerce and integration tools like enterprise resource planning (ERP).

CHEMICAL REACTION ENGINEERING

Group A

Classification of reactors and reactions. Definition of reaction rate, variables affecting the rate, Rate theories the Arrhenius relationship. Collision theory and activated complex theory.

Order of reaction and its determination. Interpretation of kinetic data for batch and flow systems. Integral and differential methods of analysis.

Design of batch, semi-batch and flow reactors for ideal single reactions, reaction in series and in parallel and mixed reactions- all under isothermal conditions.

Group B

Comparison of performance of CSTR with PER. The effect of volume change during the reaction. Re-active distillation. Membrane reactor. Introduction to design of adiabatic and non-isothermal reactor. Kinetics and typical examples of uncatalyzed heterogeneous reactions.

Properties of catalysts and their determination. Classification of catalysts. general procedure for manufacture of catalysts. Promoters, inhibitors and poisons. Mechanism of catalyzed

reactions. Design of fixed bed and fluidized bed catalytic reactors under isothermal conditions.

Introduction to non-ideal reactors. Residence time distribution, dispersion model and its solution for different boundary conditions.

Recommended Books

- J M Smith. Chemical Engineering Kinetics. McGraw-Hill International.
- Levenspiel. Chemical Reaction Engineering. McGraw-Hill International.

TRANSPORT PHENOMENA

Group A

Momentum transport: Physical properties of fluids, forces on fluids, buoyancy, hydrostatic equation for compressible fluids. Laws of viscosity. Types of fluid motion-flow through pipes and channels. Bernoulli's theorem. Conservations of mass and momentum head loss in fittings. Solution of pipe flow problems. Differential balances in Cartesian coordinates. Navier-Stokes equation. Solution of Navier-Stokes equation for simple cases. Creeping flow.

Turbulent flow: Nature and intensity of turbulence. Universal velocity distribution. Flow through rough pipes. Boundary layer flow solution for laminar and turbulent flows. Flow past immersed bodies. Application of dimensional analysis in fluid dynamics.

Group B

Energy Transport: Thermal conductivity. Steady and unsteady state heat conduction in one-dimensional system. Convective heat transfer coefficients. Heat transfer with laminar flow over a flat wall and through pipes. Heat transfer with turbulent flow. Condensation and boiling heat transfer. Analogies between momentum and heat transfer.

Mass Transport: Theories of diffusion. Component mass balance. Convective mass transfer coefficients. Mass transfer with laminar flow and with turbulent flow over a flat wall. Analogies between momentum and mass transfer. Simultaneous momentum, heat and mass transfer.

Recommended Books

- R B Bird, W E Stewart and E N Lightfoot. Transport Phenomena Wiley International.
- C O Bennett and J E Myers. Heat and Momentum Transport. McGraw-Hill International.

CHEMICAL ENGINEERING THERMODYNAMICS

Group A

First law: Evaluation of P-V-T properties of fluids. Law of corresponding state. Residual volume, compressibility factor. Equations of state. Heat effects. Clausius-Clapeyron equation.

Second Law: Entropy. Carnot cycle. Work function. Free energy. Phase rule-its use in study of multi component systems.

Group B

Refrigeration. Thermodynamic efficiency. Production of work from heat. Partial molal properties. Chemical potential. Fugacity.

Activity and activity coefficients. Gibbs- Duhem equation. Determination of activity coefficients from van Laar equations. Chemical reaction equilibria. Introduction to Third Law.

Recommended Books

- **J M Smith and H C Van Ness. Introduction to Chemical Engineering Thermodynamics. McGraw-Hill International.**
- **E Balzhiser and R Samuels. Engineering Thermodynamics. Prentice-Hall of India (P) Ltd., New Delhi.**

CHEMICAL PROCESS PRINCIPLES

Group A

Graphical methods of curve fittings, method of least squares, solution of cubic equations by trial and error method. Conversation of units. Dimensional analysis. Properties of gas, liquid and solid. Equations of state.

Vapour pressure. Vapour pressure plots, Vapour pressure of immiscible liquids and vapour pressure of solutions. Humidity and saturations humidity chart. Super saturations. Distribution of a solute between immiscible and partially miscible liquids. Solubility of gases.

Group B

Materials balance: Concepts of limiting and excess reactants, batch, stage-wise, Continuous and recycle operations. Material balance of systems involving mixing, extraction, distillation, crystallization, chemical reaction and recycle processes.

Heats of formation, combustion, reaction, solution, dilution, etc. Effect of temperature on heat of reaction. Energy balance of systems without and with chemical reactions. Material and energy balance calculations for simple processes like manufacture of sulphuric acid, nitric acid and alkali.

Recommended Books

- **A Hougen, K M Watson and R A Ragatz. Chemical Process Principles-Part 1. Asian Publishing House, Mumbai.**
- **S K Ghoshal, S K Sanyal and S Dutta. Introduction to Chemical Engineering. Tata McGraw-Hill publishing Co. Ltd., New Delhi.**
- **B I Bhatt and S M Vora. Stoichiometry. Tata McGraw-Hill publishing Co. Ltd., New Delhi.**

CHEMICAL ENGINEERING EQUIPMENT DESIGN

Group A

Process equipment supports. Storage tanks and pressure vessels.

Heat transfer equipment. Concentric pipe, shell and tube, single-pass and multi-pass heat exchangers; Condensers.

Group B

Single and multiple effect evaporators. Plate and frame filter press.

Mass transfer equipment . Absorption and distillation columns; Rotary dryers.

Recommended Books

- **D O Kern. Heat Transfer. McGraw-Hill International.**
- **R E Treybal. Mass Transfer Operations. McGraw-Hill International.**
- **R K Sinnott. An introduction to Chemical Engineering Design in Chemical Engineering: Vol 6. Couper and Richardson Series, Pergamon Press, Oxford.**

MASS TRANSFER OPERATIONS

Group A

Principles and theories of mass transfer. Mass transfer coefficients and their correlations. J D Factor and HTU concepts. Absorption, principles, packing materials. Flooding and loading points. HETP and HTU concepts. Absorption concepts and qualitative treatment.

Distillation: Batch, continuous, flash, vacuum, steam, molecular, azeotropic, extractive and multi-component distillation. Theory of fractional distillation of binary mixtures. Calculation of number of theoretical plates. Plate efficiency. Minimum and optimum reflux.

Group B

Crystallization: Factors influencing nucleation and crystal growth. Caking of crystals. Different crystallizers and their design principles.

Extraction: Batch and continuous. Calculation of number of ideal stages. Multistage extraction. Equipment and their design principles.

Drying: Theory and mechanism of drying, drying rates, different dryers and their design principles. Wet and dry bulb hygrometry. Humidification and dehumidification. Air-conditioning. Cooling.

Recommended Books

- **R E Treybal. Mass Transfer Operations. McGraw-Hill International.**
- **W L McCabe and J C Smith. Unit Operations of chemical Engineering. McGraw-Hill International.**

HEAT TRANSFER OPERATIONS

Group A

Fouriers' laws of conduction. Steady state conduction of heat through solids. Steady state heating and cooling of liquids. Convection-free and forced. Heat transfer from vertical surfaces and rotating bodies.

Heat transfer from condensing vapours and boiling liquids-filmwise and dropwise. Boiling coefficients. Fouling factors. Heat exchange equipment like heat exchangers, condensers and waste heat boilers. Heat transfer is stirred tanks.

Group B

Heat transfer by radiation-black body and grey body radiation, laws of radiation. Shape factor. Combined heat transfer coefficients with convection and radiation.

Evaporation: Various types of evaporation and their attachments, performance of evaporators, boiling point rise. Single and multiple effects. Forward feed, backward feed and mixed feed. Vapour compression evaporation. Barometric condensers.

Recommended Books

- **D Q Kern. Process Heat Transfer. McGraw-Hill International.**
- **W L McCabe and J C Smith. Unit Operations of Chemical Engineering. McGraw International.**
- **S P Sukhatme. A textbook on Heat Transfer. Orient Longman Ltd., New Delhi.**

MECHANICAL OPERATIONS

Group A

Classifications and performance of pumps, blowers, compressors and turbines-their selection and specifications. Mechanical and pneumatic conveying equipment and power consumption. Design of conveyor belts.

Theories of filtration-constant rate and constant pressure filtration. Optimum cycle, compressible cakes and filter aids. Centrifugation. Flow through packed beds. Fluidization.

Group B

Size reduction-types of equipment and their studies. Closed and open circuit grinding. Laws of crushing and grinding, power requirements, Screening-equipment and efficiency. Sedimentation-free and hindered setting. Cyclones and electrostatic precipitator. Flotation. Thickeners.

Mixing equipment and characteristics, power consumption and efficiency. Measurements of fluid flow by weir, V-notch, orifice meter, venture meter, pitot tube and rotameter.

Recommended Books

- W L McCabe and J C Smith. Unit operations of chemical Engineering. McGraw-Hill International.
- A M Gaudin. Principles of Mineral Dressing. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

FLUID MECHANICS

Group A

Introduction. Shear stress, viscosity, kinematic viscosity, dependence of viscosity on temperature and pressure. Ideal fluid.

Fluid statics: Pressure hydrostatics. Forces on submerged surfaces and bodies. Manometers. Dimensional analysis and similitude. Buckingham pi theorem, methods to determine dimensionless groups. Reynold, Froude and mach numbers.

General description of fluid motion. Types of flows, streamlines and stream tubes. Dynamics of fluids in steady motion. Equation of continuity and momentum, momentum correction factor. Bernoulli's equation. Application of continuity, momentum and Bernoulli's equation to physical situations.

Group B

Flow in pipes, Poiseuille's equation; kinetic energy correction factor; friction factor; hydraulic radius; D'Arcy-Weisbach formula. Equivalent resistance of valves and fittings. Expansion and contraction losses.

Flow around immersed bodies. Boundary layers-laminar and turbulent. Pressure distribution. Drag and lift-form drag; drag coefficient; drag coefficient as a function of Reynold's number. Stoke's law. Terminal velocity. Compressible flow: Qualitative treatment only.

Recommended Books

- W L McCabe and J C Smith. Unit Operations of Chemical Engineering. McGraw-Hill International.
- V L Streeter and E B Wylie. Fluid Mechanics. McGraw-Hill International.
- V Gupta and S K Gupta. Fluid Mechanics and Its Applications. New Age International (P) Ltd; New Delhi.

INSTRUMENTATION AND CONTROL

Group A

Temperature measuring instruments. Bimetallic, vapour pressure, thermocouples, resistance thermometer, radiation pyrometer, optical pyrometer, photoelectric pyrometer, thermistor, Response of these instruments. Instrument performance characteristics and evaluation.

Composition measuring instruments. Spectroscopic method, thermal conductivity cell, carbon dioxide analyzer, fuel gas analysis, oxygen analysis, pH meter, refractometer, chromatograph, colorimetry and polarograph. Response of these instruments. Instrument performance characteristics and evaluation.

Measurement of pressure and volume. Manometer pressure spring, Mcleoid gauge. Pirani gauge, ionization gauge and liquid seals. Response of these instruments. Viscosity

measurement, specific gravity measurement, level measuring devices, flow measuring devices, measurement of displacement and density.

Group B

Transfer functions and input-output models. Dynamic response to step inputs of first and second order systems with or without time lags. Feedback control and effect of proportional, integral and derivative control.

Root-locus analysis and stability of feedback controlled systems. Frequency response of systems. Bode diagrams, Ziegler-Nichols methods.

Recommended Books

- D P Eckman. Industrial Instrumentation. New Age International (P) Ltd; New Delhi.
- P Harriot. Process Control. Tata McGraw-Hill Publishing Co. Ltd; New Delhi.
- A Suryanarayana. Outlines of Chemical Instrumentation and Process Control. Khanna Publishers; Delhi.

FUELS AND COMBUSTION

Group A

Introduction to different energy sources-conventional and non-conventional.

Coal technology: Origin of coal, its classification. Washing, briquetting and carbonization. Liquid fuels. Petroleum and prepared liquid fuels. Synthetic liquid fuels, Storage, handling, utilization and testing.

Group B

Gaseous fuels: Natural gas, LPG, manufactured gases such as producer gas, water gas and hydrogen. Coal gasification.

Combustion and furnaces. Stoichiometry, combustion thermodynamics, propagation of flame and combustion appliances. Fluidized bed combustion. Elementary concepts of furnace design. Regenerators and recuperators.

Recommended Books

- S P Sharma and M Chander. Fuels and Combustion. Tata McGraw-Hill Publishing Co. Ltd; New Delhi.
- S Sarkar. Fuels and Combustion. Orient Longman Ltd; New Delhi.

BIOCHEMICAL ENGINEERING

Group A

Scope and importance of biochemical engineering and biotechnology. Micro-organisms: Structures, composition and activity. Kinetics of cell growth-Monod equation.

Metabolic pathways and bioenergetics.

Enzymes: Biocatalysts, immobilized enzymes, enzyme kinetics-Michaelis-Menten equation. Sequential enzyme reactions, regulation of enzyme activity.

Group B

Transport phenomena in microbial systems.

Fermentation: Process parameters, sterilization, Process control.

Bioreactors: Different types-design and scale up.

Cellular genetic, genetic manipulation, principles of recombinant. DNA technology.

Important biochemical products-their manufacturing procedures and uses.

Recommended Books

- **F C Webb. Biochemical Engineering. Van Nostrand Publishing Co.**
- **J E Bailey and D F Ollis. Biochemical Engineering Fundamentals. McGraw-Hill International.**

MECHANICAL OPERATIONS

Group A

Classifications and performance of pumps, blowers, compressors and turbines-their selection and specifications. Mechanical and pneumatic conveying equipment and power consumption. Design of conveyor belts.

Theories of filtration-constant rate and constant pressure filtration. Optimum cycle, compressible cakes and filter aids. Centrifugation. Flow through packed beds. Fluidization.

Group B

Size reduction-types of equipment and their studies. Closed and open circuit grinding. Laws of crushing and grinding, power requirements, Screening-equipment and efficiency. Sedimentation-free and hindered setting. Cyclones and electrostatic precipitator. Flotation. Thickeners.

Mixing equipment and characteristics, power consumption and efficiency. Measurements of fluid flow by weir, V-notch, orifice meter, venture meter, pitot tube and rotameter.

Recommended Books

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- **A M Gaudin. Principles of Mineral Dressing. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.**

CHEMICAL PROCESS TECHNOLOGY

Group A

Water for industries and water treatment: Boiler feed water, cooling tower water and process plant water. Water treatment by lime-soda process, flocculation, aeration, deaeration and ion exchange methods. Acid industries: Sulphuric, hydrochloric, nitric and phosphoric acids. Alkali industries: Caustic soda, sodium carbonate, chlorine and bleaching powder.

Fertilizers: Nitrogenous, phosphatic and potassic- raw materials and manufacturing process. Mixed and compound fertilizers. Superphosphates. Bio-fertilizers.

Group B

Glass, ceramics, cement and refractory industries. High polymers, including plastics, rubber and fibres- their chemistry and technology. Petroleum refinery and petrochemicals.

Oils and fats: Refining, hydrogenation, fat splitting. Soaps and detergents. Pulp and paper industries. Industrial fermentation-ethyl alcohol.

Recommended Books

- **R N Shreve. Chemical Process Industries. McGraw-Hill International.**
- **M Gopal Rao and M Sitting. Dryden's Outlines of Chemical Technology. Affiliated East-West Press (P) Ltd; New Delhi.**
- **V Gupta and S K Gupta. Fluid Mechanics and Its Applications. New Age International (P) Ltd; New Delhi.**

INSTRUMENTATION AND CONTROL

Group A

Temperature measuring instruments. Bimetallic, vapour pressure, thermocouples, resistance thermometer, radiation pyrometer, optical pyrometer, photoelectric pyrometer, thermistor, Response of these instruments. Instrument performance characteristics and evaluation.

Composition measuring instruments. Spectroscopic method, thermal conductivity cell, carbon dioxide analyzer, fuel gas analysis, oxygen analysis, pH meter, refractometer, chromatograph, colorimetry and polarograph. Response of these instruments. Instrument performance characteristics and evaluation.

Measurement of pressure and volume. Manometer pressure spring, Mcleoid gauge. Pirani gauge, ionization gauge and liquid seals. Response of these instruments. Viscosity measurement, specific gravity measurement, level measuring devices, flow measuring devices, measurement of displacement and density.

Group B

Transfer functions and input-output models. Dynamic response to step inputs of first and second order systems with or without time lags. Feedback control and effect of proportional, integral and derivative control.

Root-locus analysis and stability of feedback controlled systems. Frequency response of systems. Bode diagrams, Ziegler-Nichols methods.

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- **P Harriot. Process Control. Tata McGraw-Hill Publishing Co. Ltd; New Delhi.**
- **A Suryanarayana. Outlines of Chemical Instrumentation and Process Control. Khanna Publishers; Delhi.**

POLYMER MATERIALS AND TECHNOLOGY

Group A

Genesis of polymers, chemistry of polymerization. Chain and step polymerization, polymerization techniques. Co-polymerisation.

Kinetic of polymerization, molecular weight, glass transition temperature. Crystallinity.

Polymer rheology. Viscosity, apparent viscosity, Newtonian and non-Newtonian fluid, power law, visco elastic behaviours.

Polymer characterization. Polymer synthesis, molecular weight method and gpc, thermal analysis.

Polymer degradation. Thermal, mechanical, UV radiation, oxidative and hydrolytic degradation.

Group B

Plastic material and processing technology. Polyethylene, polypropylene, polystyrene, PVA, PVC Polyurethane.

Plastic processing. Mixing, molding, extrusion.

Rubber material and processing technology. Natural and synthetic rubber. Thermoplastic elastomers.

Rubber processing : Compounding , vulcanization (mixing), molding , extrusion , calendaring.

Identification , testing and evaluation of plastic and rubber. Identification of common plastic and rubbers. Physical testing – stress-strain tear, hardness, resilience. Flexing , abrasion and impact testing. Electrical properties, Resistivity dielectric constant , power factor.

Recommended Books

- **P Ghosh. Polymer Science and Technology. Tata McGraw Publishing Co. Ltd., New Delhi.**
- **F B Billmeyer. Textbook of Polymer Science. Wiley Interscience, New Delhi.**
- **J R Fried. Polymer Science and Technology. Prentice-Hall of India (P) Ltd., New Delhi.**
- **V R Gowarikar, N V Viswanathan and J Sreedhar. Polymer Science. New Age International (p) Ltd., New Delhi.**

PETROCHEMICAL ENGINEERING

Group A

Origin, occurrence, composition and physical properties of petroleum. Evaluation of oil stocks. Petroleum refining processes-topping and vacuum distillation. Thermal cracking-vapour phase, liquid phase and mixed phase. Thermal reforming and polyforming. Catalytic cracking-fixed bed, fluidized bed and TCC. Catalytic reforming.

Conversion of petroleum gases into motor fuel with special reference to alkylation, polymerization, hydrogenation and dehydrogenation. Production of aviation gasoline, motor fuel, gasoline, kerosene, distillates, diesel oil, tractor fuel, jet fuel and fuel oil. Octane number, cetane number, diesel index-their determination and importance.

Group B

Lube manufacture-vacuum distillation, solvent extraction, uses of lubes. Petroleum waxes. Chemical and clay treatment of petroleum products. Natural gas. Carbon black.

Petrochemicals-manufacture of a few important petrochemicals and their uses. Elementary study of multi-component distillation as applied to petroleum refineries. Specifications and testing of refinery products.

Recommended Books

- **W L Nelson. Petroleum Refinery Engineering. McGraw-Hill International.**
- **P Belov. Fundamentals of Petroleum Chemical Technology. Mir Publishers, Moscow.**
- **B K Bhaskara Rao. Modern Petroleum Refining Process. Oxford and IBH Publishing Co (P) Ltd., New Delhi.**

INDUSTRIAL POLLUTION AND CONTROL

Group A

The ecosystem. Effect of polluted environment on ecosystem. Classification of pollutants. Sources of pollutants. Toxic chemicals and other industrial wastes. Methods of estimation of pollutants.

Approach to air pollution control. Pollution control techniques with reference to gaseous, liquid and solid pollutants. Control equipment for particulate emission. Solid waste treatment and management. Pollution control with recycling.

Group B

Waste water and sludge treatments. Treatment of industrial wastes from typical chemical industries. Pollution control industries like acid, alkali, fertilizer, paper and pulp, food, petrochemicals, leather tanning and brewery industries.

Elementary microbiology related to pollution and pollution control. Aerobic and anaerobic process. Pollution control legislation.

Recommended Books

- **G N Pandey and G C Carrey. Environmental Engineering. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.**
- **S P Mahajan. Pollution Control in Process Industries. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.**

FERTILIZER TECHNOLOGY

Group A

Soil fertilizer interaction. Importance of fertilizers. Fertilizers recommended for various crops.

Nitrogenous fertilizers. Feed stock for ammonia production and synthesis gas production-production procedures. Manufacture of ammonia, urea and other nitrogenous fertilizers.

Phosphatic fertilizers: Raw materials, single and triple superphosphate manufacture.

Pottassic fertilizers: Raw materials and sources. production of important potassic fertilizers.

Group B

Mixed N-P-K fertilizers, granulated fertilizers and compound fertilizers-production procedure.

Micronutrients: Production and applications.

Organic fertilizers: Compost and biofertilizers, comparative study with chemical fertilizers. Pollutional problems in fertilizer industries and their control.

Recommended Books

- **R N Shreve. Chemical Process Industries. McGraw-Hill International.**
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