PHARMACOLEARN

It's Important to Know!

BP304T — Pharmaceutical Engineering

B.Pharm Semester 3
3 hrs/week · 4 credits · 45 hours · 100 marks (25 internal + 75 end-semester, 3 hr paper)

Complete notes — all 5 units in one PDF

- Unit 1 — Flow of fluids, size reduction and size separation
- Unit 2 — Heat transfer, evaporation and distillation
- Unit 3 — Drying and mixing
- Unit 4 — Filtration and centrifugation
- Unit 5 — Materials of construction and corrosion

Free download from PharmacoLearn

Visit this subject on pharmacolearn.fyi

https://pharmacolearn.fyi/b-pharm/semester-3/bp304t-pharmaceutical-engineering/

Share freely — please keep the PharmacoLearn link intact, so students always find the latest notes.

PHARMACOLEARN

It's Important to Know!

BP304T — Pharmaceutical Engineering

B.Pharm Semester 3 · Unit 1 — Flow of fluids, size reduction and size separation

Unit I: Flow of fluids, size reduction and size separation

Flow of fluids

Fluid flow may be steady or unsteady, uniform or non-uniform, and laminar or turbulent. A manometer measures pressure difference using a liquid column. Reynolds number relates inertial and viscous effects and helps classify flow, although the transition range depends on geometry and conditions.

Bernoulli's theorem expresses conservation of mechanical energy for an idealised flowing fluid. Real systems lose energy through friction, fittings and changes in area. Orifice meters and Venturimeters infer flow from pressure changes. A Pitot tube relates stagnation and static pressure to fluid velocity. A rotameter uses a float in a tapered tube and requires suitable calibration.

Size reduction

Size reduction increases surface area, improves mixing, supports extraction or dissolution and produces a required powder range. Particles may break by compression, impact, attrition, cutting or combined mechanisms. Kick, Rittinger and Bond relationships describe different idealised energy-size relationships. The useful law depends on material and size range.

Hammer mills use impact, ball mills use impact and attrition, fluid-energy mills use high-velocity gas, and edge-runner or end-runner mills use compression and shearing. Feed moisture, hardness, toughness, stickiness, speed and heat sensitivity affect performance.

Size separation

Size separation classifies particles by size or settling behaviour. Sieves provide a defined aperture range. Cyclone and air separators use fluid forces, while bag filters collect particles from air and elutriation uses an upward fluid stream. Powder standards and sieve terminology are set out in the applicable pharmacopoeia.

Unit I: Frequently asked questions

Q: What does Reynolds number help predict?

A: It compares inertial and viscous effects and helps indicate whether flow is likely to be laminar or turbulent in a defined system.

Q: Why does size reduction improve dissolution?

A: It can increase surface area, reducing the distance for mass transfer, although wetting and solid form still matter.

Q: How does a cyclone separate particles?

A: A rotating gas flow creates centrifugal effects that drive larger or denser particles toward the wall for collection.

Unit I: Key takeaways

- Fluid meters infer flow from pressure, velocity or float position.
- Real fluids lose energy through friction and fittings.
- Size reduction uses impact, compression, attrition or cutting.
- Equipment choice depends on material and target particle size.
- Separation method depends on particle and fluid properties.

Unit I: Practical correlation

Practical correlation: powder milling. A mill should be selected after considering heat generation, dust, contamination risk, feed properties and desired particle-size distribution. The appropriate equipment and screen setting are set out in the approved specification for the product.

PHARMACOLEARN

It’s Important to Know!

BP304T — Pharmaceutical Engineering

B.Pharm Semester 3 · Unit 2 — Heat transfer, evaporation and distillation

Unit II: Heat transfer, evaporation and distillation

Heat transfer

Heat moves by conduction, convection and radiation. Fourier's law relates conductive heat flow to thermal gradient and material conductivity. Convection combines fluid motion with molecular transfer. Radiation transfers energy through electromagnetic waves and does not require a material medium. Overall heat transfer also depends on resistance at surfaces and fouling.

Heat exchangers transfer energy between streams without necessarily mixing them. Counter-current arrangements can provide a useful temperature driving force. Equipment selection depends on material compatibility, viscosity, fouling and cleaning requirements.

Evaporation

Evaporation removes solvent by vaporisation to concentrate a solution. It differs from drying because the feed is usually a liquid solution and the product is a concentrated liquid. Steam-jacketed kettles, horizontal-tube, climbing-film, forced-circulation and multiple-effect evaporators use different circulation and heat-transfer arrangements.

Factors include temperature difference, pressure, viscosity, foaming, scaling, residence time and thermal sensitivity. Multiple-effect systems reuse vapour heat and can improve steam economy, but require more control and may increase residence time.

Distillation

Distillation separates volatile components using vapour-liquid equilibrium. Simple distillation suits a large volatility difference or a volatile component from non-volatile material. Fractional distillation uses repeated vaporisation and condensation. Flash distillation is a single equilibrium stage. Reduced-pressure distillation lowers boiling temperature. Steam distillation suits certain water-immiscible volatile substances. Molecular distillation uses a short path and very low pressure. Exact equipment limits should be checked against the manufacturer's instructions.

Unit II: Frequently asked questions

Q: What are the three modes of heat transfer?

A: They are conduction, convection and radiation.

Q: Why can multiple-effect evaporation save steam?

A: Vapour generated in one effect can supply heat to another effect operated at a lower pressure and boiling temperature.

Q: When is reduced-pressure distillation useful?

A: It is useful when lowering the boiling temperature may protect a heat-sensitive material or permit separation at lower operating temperature.

Unit II: Key takeaways

- Heat transfer depends on driving force and thermal resistance.
- Evaporation concentrates a solution by removing solvent.
- Distillation depends on volatility and vapour-liquid equilibrium.
- Pressure reduction can lower boiling temperature.
- Fouling, foaming and thermal degradation must be controlled.

Unit II: Practical correlation

Practical correlation: concentration of a heat-sensitive solution. Vacuum operation, short residence time and suitable circulation may reduce thermal stress, but the process must be validated for potency and impurities. The operating range is set out in the validated procedure.

PHARMACOLEARN

It’s Important to Know!

BP304T — Pharmaceutical Engineering

B.Pharm Semester 3 · Unit 3 — Drying and mixing

Unit III: Drying and mixing

Drying principles

Drying removes moisture or another volatile liquid by heat and mass transfer. Moisture may be free, capillary-held, adsorbed or bound. Equilibrium moisture content is the moisture remaining when a solid equilibrates with surrounding conditions. A drying curve commonly shows an initial adjustment, constant-rate period and falling-rate period, but the exact curve depends on material and process.

Tray dryers use heated air over trays. Drum dryers form a film on a heated surface. Spray dryers atomise a feed into hot gas and can produce powders rapidly. Fluidised-bed dryers suspend particles in air and provide good contact. Freeze drying removes ice by sublimation under reduced pressure after freezing, helping preserve heat-sensitive materials but requiring long cycles and control of collapse.

Mixing

Mixing aims to reduce concentration differences. Liquid mixing may use impellers that create axial, radial or mixed flow. Semisolid mixing requires torque and suitable blade geometry. Solid mixing involves convection, diffusion and shear, while segregation can occur because of differences in size, density or shape.

Mixing time, order of addition, fill level, speed, viscosity and scale affect uniformity. Overmixing can cause heat, aeration, segregation or particle damage. Equipment-specific selection is set out in the approved specification for a named product.

Unit III: Frequently asked questions

Q: What is equilibrium moisture content?

A: It is the moisture content at which a material is in balance with the surrounding air under specified temperature and humidity.

Q: Why can spray drying produce a powder from a liquid feed?

A: Atomisation creates droplets with high surface area, allowing rapid solvent evaporation in a heated gas stream.

Q: What causes segregation after powder mixing?

A: Differences in particle size, density, shape, flow or vibration can cause components to separate after mixing.

Unit III: Key takeaways

- Drying combines heat transfer with movement of moisture through and from a solid.
- Drying rate depends on material structure and air conditions.
- Spray and fluidised-bed dryers have different particle and residence-time effects.
- Mixing reduces concentration gradients but can also promote segregation.
- Scale-up must preserve the relevant process variables.

Unit III: Practical correlation

Practical correlation: granule drying. Drying should target a moisture range that supports flow and compression without causing degradation or over-drying. The product-specific endpoint and sampling plan are set out in the approved specification.

PHARMACOLEARN

It’s Important to Know!

BP304T — Pharmaceutical Engineering

B.Pharm Semester 3 · Unit 4 — Filtration and centrifugation

Unit IV: Filtration and centrifugation

Filtration

Filtration separates solids from fluids through a porous medium. The driving force may be pressure difference, vacuum, gravity or centrifugal force. Cake filtration forms a layer of retained solids; depth filtration captures particles within the medium. Darcy-type relationships show that rate depends on pressure, viscosity, area and resistance.

Filter media may be woven, non-woven, porous ceramic, membrane or other compatible material. Filter aids can improve cake permeability and reduce blinding. Plate-and-frame, leaf, cartridge, rotary drum and membrane systems serve different duties. Integrity testing, compatibility, adsorption and extractables matter for pharmaceutical filtration.

Centrifugation

Centrifugation accelerates sedimentation by applying a centrifugal field. Separation depends on particle size, density difference, fluid viscosity, rotor speed and path length. Perforated basket centrifuges retain solids while liquid drains through openings. Non-perforated baskets may handle liquid-liquid or fine separation. Semi-continuous and supercentrifuges provide higher throughput or force. Exact equipment classification should be checked against the prescribed text.

Selection and validation

Filter or centrifuge selection should consider feed properties, desired clarity, solids loading, shear, temperature, cleaning, containment and scale. A filtration or centrifugation endpoint must be linked to a quality attribute such as clarity, bioburden, particle count or yield.

Unit IV: Frequently asked questions

Q: What is filter-cake resistance?

A: It is the resistance to fluid flow created by the deposited solids layer, which usually increases as the cake builds.

Q: Why are filter aids used?

A: They can form a more permeable cake and reduce clogging or blinding of the primary medium.

Q: What controls sedimentation in a centrifuge?

A: Particle size, density difference, fluid viscosity, centrifugal acceleration and residence time are major factors.

Unit IV: Key takeaways

- Filtration separates by flow through a porous medium.
- Cake and medium resistance both affect filtration rate.
- Centrifugation increases the effective settling force.
- Integrity and compatibility are essential for pharmaceutical filters.
- Equipment should be selected against a defined quality endpoint.

Unit IV: Practical correlation

Practical correlation: sterile filtration. A sterile filtration process requires validated filter compatibility, integrity testing, controlled connections and an appropriate bioburden strategy. The required pore size and validation package are set out in the validated procedure for the product.

PHARMACOLEARN

It's Important to Know!

BP304T — Pharmaceutical Engineering

B.Pharm Semester 3 · Unit 5 — Materials of construction and corrosion

Unit V: Materials of construction and corrosion

Materials

Pharmaceutical equipment may use metals, glass, plastics, elastomers or composite materials. Selection considers strength, temperature, pressure, corrosion resistance, cleanability, surface finish, extractables, leachables and compatibility with product and cleaning agents. Ferrous and non-ferrous metals differ in iron content and performance. Specific grade selection should be checked against the material specification.

Glass can provide chemical resistance and transparency but may be fragile. Plastics may be light and corrosion-resistant but can absorb substances, swell or release extractables. Elastomers require attention to compatibility and compression set. Material claims must be linked to the actual grade and process.

Corrosion

Corrosion is deterioration caused by chemical or electrochemical reaction with the environment. It may be uniform, galvanic, pitting, crevice, intergranular, erosion-corrosion or stress-related. Water, oxygen, acids, alkalis, salts, temperature, differential metals and surface damage can influence rate.

Control methods include material selection, passivation, coatings, inhibitors, cathodic or anodic protection, design that avoids stagnant zones, and control of cleaning and process conditions. A control method must not introduce product contamination.

Plant layout and material handling

Plant layout should support logical movement of people and materials, segregation, cleaning, maintenance, utilities, safety and waste control. Material handling may use conveyors, bins, pumps, lifts or pneumatic systems. Dust, cross-contamination, ergonomic risk and containment must be considered.

Unit V: Frequently asked questions

Q: What is galvanic corrosion?

A: It is electrochemical corrosion that can occur when dissimilar conductive metals contact each other in an electrolyte.

Q: Why is stainless steel grade important?

A: Composition and surface condition influence corrosion resistance, cleanability and compatibility with the process environment.

Q: What is the purpose of plant layout design?

A: It organises people, materials, equipment, utilities and waste so that safety, quality, flow and maintenance are supported.

Unit V: Key takeaways

- Material selection is a product-contact and process decision.
- Corrosion may be chemical, electrochemical or mechanically assisted.
- Stagnant zones and dissimilar metals can increase risk.
- Layout affects contamination control, safety and efficiency.
- Grade-specific compatibility must be verified.

Unit V: Practical correlation

Practical correlation: equipment qualification. A product-contact vessel should be assessed for material grade, surface finish, cleaning, corrosion, extractables and maintenance history. The acceptance criteria are set out in the approved specification.