MIXING

1. Which among the following is an example of high shear mixer: [GPAT 2024]

(a) Sigma blade mixer
(b) Turbine mixer
(c) Jet mixer
(d) Nauta mixer

2. Match List I with List II

List - 1 (Equipment)	List II (Model/Trade Name/Type)
1. Low shear mixer	[P] Manestry Drycota
2. Rotary tablet machine	[Q] Chilsonator (Fitzpatrick)
3. Capsule filling machine	[R] Slated Double Cone Mixer
4. Compaction mill	[S] Prosolv (JRS Pharma)
	[T] PCF 1200 Model (Pharma Land)

Choose the correct answer from the options given below [GPAT-2021]

(a) 1-[P], 2-[Q], 3 - [R], 4- [S]
(b) 1 - [Q], 2- [R], 3 - [P], 4 - [S]
(c) 1-[R], 2-[P], 3 - [S], 4- [Q]
(d) 1 - [P], 2 - [Q], 3 - [S], 4 - [R]

3. The dispersion of course material by shearing in a narrow gap between a static cone and rapidly rotating cone is caused by [GPAT-2020]

(a) Colloid Mill
(b) Electrical Dispersion
(c) Peptization
(d) Ultrasonic Irradiation

4. In solid-solid mixing, large scale continuous type of mixer is [GPAT-2020]

(a) Sigma blender
(b) Ribbon blender
(c) Zigzag blender
(d) Twin shell blender

5. In Direct- Contact or Jet condensers, barometric leg serves one of the following functions [GPAT-2019]

(a) To remove the condensate/cooling water mixture
(b) To measure the pressure difference across the tube
(c) To Heat the liquid feed to ifs boiling point
(d) To transfer the feed in to the evaporating chamber

6. Statement 1: Vortex formation can be minimized by push pull mechanism
Statement 2: Vortex formation reduces the mixing intensity by increasing the velocity of impeller [GPAT-2018]

(a) True, False
(b) True, True
(c) False, False
(d) False, True

7. Mixing of semisolids is carried out using [GATE-2005]

(a) Double cone mixer
(b) Rotating cube mixer
(c) Planetary mixer
(d) Fluidized bed mixer

8. Thermolabile immiscible liquid can be separated by [GATE-1990]

(a) Decantation
(b) Dilution
(c) Capacity centrifugation
(d) Counter current distribution

9. Which mixing equipment produce tumbling as a mechanism in solid- solid mixing

(a) Fluidized mixer
(b) Ribbon blender
(c) Sigma blender
(d) V-Cone blender

10. What is the shape of mixing element present in Zig-zag mixer

(a) Cube shape
(b) Double cone shape
(c) Sigma shape
(d) V-shape

FILTRATION

1. The fluid flows through the filter medium by virtue of [GPAT-2023 SHIFT-11]

(a) Pressure difference across the filter
(b) Temperature difference across the filter
(c) Volume difference across the filter
(d) Potential difference across the filter

2. The relation between emissive power of the surface and its absorptivity is given by [GPAT-2019]

(a) Stefan - Boltzmann Law
(b) Darcy's Law
(c) Fourier's Law
(d) Kirchhoff's Law

3. The suitable filtration equipment's is

(a) Plate and frame filter press
(b) Leaf filters
(c) Meta filters
(d) Membrane filters

4. The filter aid used in the above filtration is

(a) Sand
(b) Nylon fiber cloth
(c) Activated carbon
(d) Filter paper

5. A suitable evaporator is

(a) Falling film evaporator
(b) Forced circulation evaporator
(c) Vertical evaporator
(d) Horizontal evaporator

6. Edge filter also called as

(a) Plate and Frame
(b) Ring Filter
(c) Meta Filter
(d) Edge Runner Filter

7. Drying is done in drum filter mainly by

(a) Vacuum
(b) Pressure
(c) Surface Area
(d) All the above

8. The process of separating the solids whose concentration is less than 1% w/v in the solvent

(a) Filtration
(b) Ultra Filtration
(c) Surface Filtration
(d) Clarification

9. Which types of pressure filtration avoids foaming

(a) Positive
(b) Negative
(c) Elevated
(d) Graded

10. Filter aid should have

(a) Low Specific Gravity
(b) Less Viscous
(c) High Boiling Point
(d) Low Boiling Point

DRYING

1. Drying process, which of the following parameters is same as the adiabatic saturation temperature:[GPAT-2024]

(a) Absolute humidity
(b) Dew point
(c) Wet bulb temperature
(d) Relative humidity

2. The most efficient heat exchange between the particles and flowing air occurs in the [GPAT-2023 SHIFT I]

(a) Tray dryer
(b) Vacuum Dryer
(c) Fluidized bed dryer
(d) Rotary dryer

3. Which of the following DRYERS is a "static bed dryer" [GPAT-2022]

(a) Freeze dryer
(b) Fluid bed dryer
(c) Spray dryer
(d) Flash dryer acid

4. In which of the following techniques the sample is kept below triple point [GPAT-2016]

(a) Lyophilization
(b) Spray drying
(c) Spray congealing
(d) Chylom Centrifugation icrons

5. Read the following statements about lyophilization [GPAT-2012]

[P] Lyophilization cannot be done in final containers like multiple dose containers
[Q] Lyophilized product needs special methods for reconstitution
[R] Lyophilization causes protein denaturation in tissues
[S] Lyophilization is suitable for drying the thermolabile products
Choose the correct combination of statements

(a) P is true and Q, R & S are false
(b) Q is true and P, R & S are false
(c) R is true and P, Q & S are false
(d) S is true and P, Q & R are false

6. Which following drying methods is commonly used in Pharma industry for drying of soft shell capsules [GPAT-2011]

(a) Truck drying
(b) Fluid bed drying
(c) Vacuum drying
(d) Microwave drying

7. Which one of the following is the commonly used bulking agent in the formulation of freeze dried low dose drug products [GPAT-2010]

(a) Sodium chloride
(b) Mannitol
(c) Starch
(d) HPMC

8. Match the following Industrial dryers with Pharmaceutical material dried [GATE-2008]

Group I Industrial dryers	Group II Pharmaceutical material dried
1. Drum dryer	[P] Antibiotic solution
2. Fluidized bed dryer	[Q] Tablet granules
3. Spray dryer	[R] Gelatin
4. Freeze dryer	[S] Suspension of kaolin

(a) 1-[P], 2-[R], 3-[S], 4-[Q]
(b) 1-[S], 2-[Q], 3-[R], 4-[P]
(c) 1-[S], 2-[Q], 3-[P], 4-[R]
(d) 1-[R], 2-[Q], 3-[P], 4-[S]

9. In the preparation of small pox vaccine, the drying process used is [GATE-2005]

(a) Spray drying
(b) Vacuum drying
(c) Drum drying
(d) Freeze drying

10. Which one of the following dryers is known as lyophiliser

(a) Fluidised bed dryer
(b) Freeze dryer
(c) Spray dryer
(d) Vacuum dryer

MIXING

INTRODUCTION

- Mixing is a critical process in pharmacy and other industries, defined as a process that aims to create a random distribution of dissimilar particles within a system.
- One important application is the method for combining a potent drug powder with a large volume of a diluent, which is known as **Geometric dilution**.

Types of Mixtures

Type of Mixture	Characteristics	Examples
Positive Mixture	• Formed easily and spontaneously. • The components do not separate out. • This process is irreversible. • Energy is not required.	Mixing of gases, miscible liquids.
Negative Mixture	• Difficult to prepare. • The components tend to separate out. • Requires some energy to be mixed.	Emulsions, Suspensions.
Neutral Mixture	• Do not mix spontaneously. • Do not separate once mixed. • Energy is required for mixing.	Ointment, Paste.

☐ Mechanism of Mixing in Solids

Mechanism	Description
Convective Mixing	A large mass of material moves from one part of the system to another. This is also referred to as **macromixing**.
Shear Mixing	Forces of attraction are broken down, allowing each particle to move on its own between regions of different compositions and parallel to their surfaces.
Diffusive Mixing	Occurs at the interfaces of dissimilar regions. It is also known as **micromixing**.

☐ Classification of Solid Mixing Equipment

Nature of Mixer	Examples	Mechanism of Mixing
Batch type- Small scale	Mortar and pestle	Trituration
Tumbling mixers or cylindrical mixers without mixing blade	Double cone blender, V cone mixers without baffles, Cube blender	Tumbling action / Diffusive. Tumbler mixers primarily function by a diffusive mechanism.
Tumbling mixer with a mixing blade	V cone blender with a mixing blade, Double cone blender with a mixing blade	Tumbling action as well as shearing with blade
Static mixers	Ribbon blender, Sigma blender, Planetary paddle	Stationary shell and rotating blade
Air mixers or fluidized mixers	Fluidized mixer	Air supported blending
Continuous type- Large scale	Barrel type, Zigzag type. The Zigzag blender is an example of a large-scale continuous type of mixer.	Rotating shell with rotating blade, shear and convection.

☐ Solid Mixing Equipment: Characteristics and Uses

Equipment	Characteristics and Uses
Ribbon blender	• The primary mechanism of mixing is **shear.** • It is fitted with two helical blades. • It is used to mix finely divided solids, wet solid mass, sticky and plastic solids. • It is also used for liquid-solid and solid-solid mixing.

Sigma blade mixer	• The mechanism involves **shear and kneading action.** • Used for mixing of dough ingredients in the baking industry. • It is used in the wet granulation process for the manufacture of tablets, pill masses, and ointments.
Planetary mixer	• The blade tears the mass apart, and shear is applied between a moving blade and a stationary wall. • Tumbling motion is also applied. • It is used for **ointment formulation**. • Operates at low speeds for dry blending and faster speeds for wet granulation.
Air mixer or fluidized mixer	• Employs a tumbling action. • Used for wet granulation in tablets.
Barrel type continuous mixer	• Employs a tumbling action.
Zigzag continuous blender	• Consists of V-shaped blenders connected in series. • The material undergoes a tumbling motion.

LIQUID MIXING

☐ Mechanisms of Liquid Mixing

Mechanism	Description
Bulk Transport	The movement of a large portion of a material from one location to another within a given system.
Turbulent Mixing	• Involves mixing due to turbulent flow. • Mixing of low-viscosity fluid of less than 10 poise is a key application of turbulent mixing.
Laminar Mixing	• The mixing of two dissimilar liquids through laminar flow, where the applied shear stretches the interface between them.
Molecular Diffusion	• Mixing at a molecular level where molecules diffuse due to thermal motion. • This is explained by Fick's law, which depends on the concentration gradient at different regions.

☐ Flow Patterns of Impellers

Impeller Type	Flow Component	Viscosity	Slurry
Propellers	Axial	2 Pascal-Sec	10% solid
Turbines	Axial or Tangential or both	700 Pascal-Sec	60% solid
Paddles	Radial and tangential, not axial	-	-
Paddles with pitch	Radial, Tangential, and axial	-	-

Mixing of Immiscible Liquids (Emulsions)

This process is primarily used in pharmacy for the manufacturing of emulsions. A fine emulsion can be obtained using equipment known as a homogenizer. Homogenizers are primarily used for size reduction.

Equipment	Characteristics and Uses
Silverson mixer- emulsifier	• Produces intense shearing force and turbulence. The Silverson Mixer-Emulsifier uses high-speed rotors and circulation to produce intense shearing force and turbulence, ensuring a rapid breakdown of dispersed liquid into smaller globules. • Used for the preparation of emulsions and creams of fine particle size.
Colloid mill	• The primary mechanism of mixing is shearing force. • It is considered a mixer as well as a milling equipment.
Ultrasonic emulsifiers- Rapisonic homogenizer	• The mechanism of mixing involves compression and rarefaction. • It has the capacity to produce dispersed globules of one-micron size. • It is particularly suitable for thermolabile substances.

Mixing of Semisolids

☐ Semisolid Mixing Equipment

Mixer Type	Equipment (Example)	Characteristic and Use
Agitator mixer	Sigma mixer	Tangential action is thoroughly obtained by two 'Z' shaped kneading blades, which rotate in opposite directions. The Sigma arm mixer is one of the most commonly used mixers for semi-solids.
	Planetary mixer	Used in food preparation to make doughs and pastes.
Shear mixer	Colloid mill	• It reduces particles to 1 micron by grinding. It contains a stator and a moving rotor. • The operational speed is 3000-20,000 RPM. • Used for lotion, emulsion, suspension, ointment, and cream.
	Triple roller mixer	• It has 3 to 5 rollers. • It is used for Cream and Ointment. • The rollers are mounted in a rigid framework horizontally.

FILTRATION

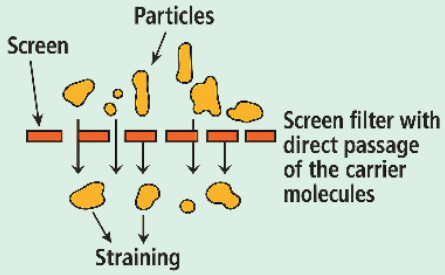
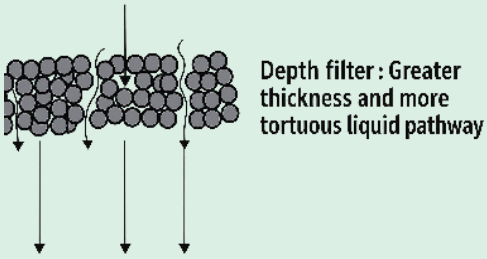
INTRODUCTION

- Filtration is defined as a process of separating solids from a fluid (either a liquid or a gas) by passing the mixture through a porous medium.
- This medium, known as the filter medium, retains the solid particles but allows the fluid to pass through.
- The fluid that passes through the filter is called the filtrate.

TYPES OF FILTRATION

Types of Filtrations	Examples	Mechanism
Surface filtration (Screen filtration)	Cellulose membrane filter	Straining and impingement
Depth filtration	Ceramic filters, sintered bed filter	Entanglement and impingement
Cake filtration	Filter cake made from diatomite (100 μm)	Straining and entanglement

☐ Difference between Surface Filtration & Depth Filtration

Basis for Comparison	Surface Filtration	Depth Filtration
Particle Retention	The size of the particles retained is slightly higher than the mean pore size of the filter medium. 	The size of the particles retained is much smaller than the pores through which the fluid passes. 
Mechanism	Works by straining and impingement.	Works by entanglement and impingement.
Particle Size Predictability	The size of the particles retained is more predictable.	The size of the particles retained is less predictable.

Mechanical Strength	The mechanical strength of the filter medium is less, unless it is made of stainless steel.	The mechanical strength is high.
Capacity	It has a low capacity.	It has a high capacity.
Cost	Equipment is expensive because it often requires ancillary equipment with finer tolerances, such as edge clamps.	Equipment is cheaper because ancillary equipment is not required.
Examples	Cellulose membrane filter	Ceramic filters, Sintered filters

Theories of Filtration

Filtration Theories & Equations

Poiseuille's Equation

Poiseuille considered that the filtration process is analogous to the streamline flow of a liquid under pressure through capillaries.

$$Q = \frac{\pi \cdot r^4 \cdot \Delta P}{8 \cdot \eta \cdot L}$$

Where:

- **Q** = Rate of flow (volume per unit time)
- **r** = Radius of the tube
- **ΔP** = Pressure difference across the tube
- **η** = Viscosity of liquid
- **L** = Length of the tub

Darcy's Equation

In Darcy's model, the length of a capillary is considered as the thickness of the filter bed. A correction factor for the radius is applied to approximate and simplify the rate equation. The factors influencing the rate of filtration have been incorporated into this equation.

$$Q = \frac{K \cdot A \cdot \Delta P}{\mu \cdot L}$$

Where:

- **Q** = Rate of flow (volume per unit time)
- **K** = Permeability constant of filter medium and cake
- **A** = Surface area of filter medium
- **ΔP** = Pressure difference across the filter
- **μ** = Viscosity of the fluid
- **L** = Thickness of the filter bed or cake

Kozeny-Carman Equation

This equation makes Poiseuille's equation applicable to a porous bed by including additional parameters to account for the capillary-like structure of the filter medium. The resultant equation is widely used for filtration calculations.

$$V = \frac{A}{\eta S^2} \times \frac{\Delta P}{KL} \times \frac{\varepsilon^3}{(1-\varepsilon)^2}$$

Where

- **V** = Superficial velocity (flow rate per unit area)
- **A** = Cross-sectional area of bed
- **η** = Viscosity of fluid
- **S** = Specific surface area of particles
- **ΔP** = Pressure drop across bed
- **K** = Kozeny constant (≈ 5)
- **L** = Thickness (length) of bed
- **ε** = Porosity (void fraction) of bed

Sieving Theory

This is a filtration theory applicable in cases where filtration occurs primarily through size exclusion and is used in the analysis of particle size distributions.

FILTRATION EQUIPMENT

Equipment	Principle/Type	Characteristics and Uses
Sintered glass filter (Candle Filter)	Depth Filtration	• Glass is made by sintering a bed of granules of borosilicate glass. Filter candles are made of borosilicate glass. • Candle filters are prepared by heat-fusing finely powdered glass particles of graded sizes. • Grade 3 and 4 are used for the clarification of non-sterile solutions. • Grade 5 is used for sterile filtration, eye drops, etc. • Cannot remove toxins and pyrogens.
Seitz filter	Surface Filtration	• Consists of a pad of compressed asbestos as a filtering medium. Asbestos is used for filtration. • It is useful for sterile filtration and air filtration. • It acts like a sieve.
Membrane filter	Surface Filtration	• Filter sheets made of cellulose are membrane filters. • The typical pore size in a membrane filter used for sterilization is 0.22 μm. • These are available with different pore sizes for various applications: ▪ 0.010 to 0.10 μm: Remove virus particles from air and water. ▪ 0.03 to 0.65 μm: Remove bacteria. ▪ 0.8, 1.2, 3.0 to 5.0 μm: Particle sizing and purifying aerosol, radioactivity.

Plate and Frame filter press	Surface Filtration	• The mechanism is surface filtration. • It provides a large surface area. • The filter media can be used repeatedly. • High filtration pressure can be used. • It is important to note that the filter press is a batch process, not a continuous one. Used for removal of precipitated proteins from insulin liquors and removal of cell broth from the fermentation medium.
Chamber press	Surface Filtration	• The mechanism is surface filtration. • Used for clarification of syrups and filtrating of injection solutions.
Filter leaf	Surface Filtration	• The mechanism is surface filtration and it acts as a sieve or strainer. • It is used to filter slurries in pharmaceuticals. • The solid content of the slurry should not be too high, about 5% (i.e., for dilute suspensions).
Metafilter (Edge filter)	Surface Filtration	• This is not an example of a bacteria-proof filter. • The Metafilter is a type of filter that operates using pressure. • It provides a large surface area for filtration. • It has considerable strength and can withstand high pressure. • Corrosive liquids can be filtered. • The cake can be easily removed. • Used for clarification of syrups and insulin liquors and filtration of injection solutions.
Cartridge filter	Straining	• The mechanism is straining. • Useful for the preparation of particulate-free solutions for parenteral and ophthalmic uses.
Drum filter (Rotary drum filter)	Surface Filtration under Vacuum	• The mechanism works on a rotating drum surface under the conditions of vacuum. • Utilized to filter slurries containing a high proportion of solids (up to 30%). • A key application is in the production of penicillins.

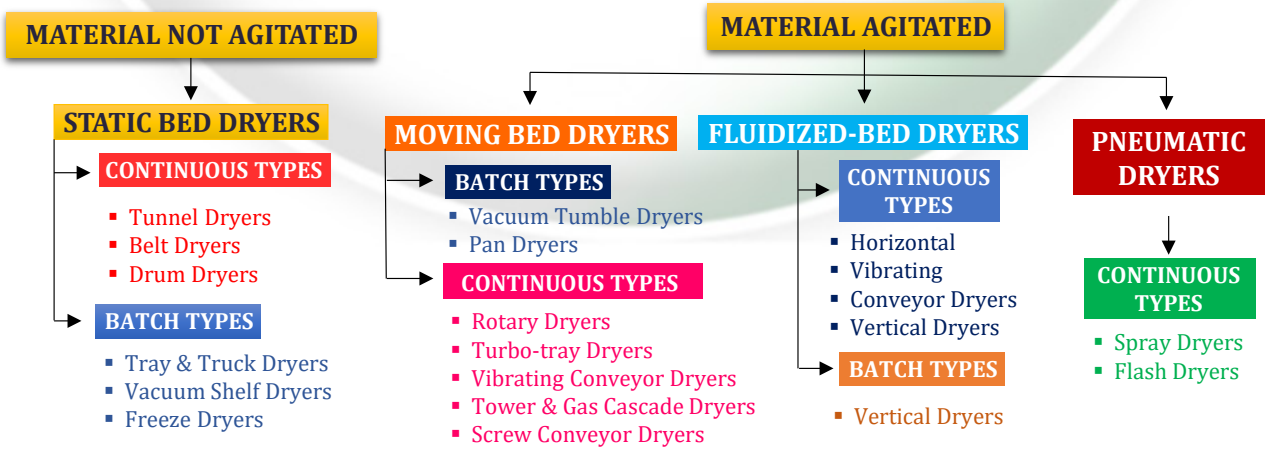
DRYING

INTRODUCTION

Drying is the process of removing small amounts of water or other liquids from a material through the application of heat to cause vaporization. The moisture content within a solid can be categorized in two ways:

- **Free Moisture Content:** This is the quantity of water that is easy or free to evaporate from the solid surface.
- **Equilibrium Moisture Content:** This is the quantity of water present in the solid that exerts a vapor pressure equal to the vapor pressure of the atmosphere surrounding it.

CLASSIFICATION OF DRYERS, BASED ON METHODS OF SOLIDS HANDLING



EQUIPMENT FOR DRYING

Drying equipment is selected based on the nature of the material to be dried, its heat sensitivity, and the desired final product characteristics.

Equipment	Type	Characteristics and Uses
Tray dryer	Static bed dryer	• Used for sticky materials, plastic substances, granular mass or crystal line materials, precipitates, and pastes. • Crude drugs, chemicals, powders, **tablet granules,** or parts of equipment are dried in this equipment.
Drum dryer	Moving bed dryer	• Used for drying solutions, slurries, and suspensions. • The products dried are **milk products** (a drum dryer is used for the production of milk powder [S]) starch products, ferrous salts, and **suspensions of zinc oxide.** • Also used for suspensions of kaolin yeast, pigments, malt extracts, granular extracts, insecticides, DDT, calcium, and **barium carbonates.**
Spray dryer	Pneumatic dryer	• An example of a pneumatic dryer. • The product is **thermolabile**, hygroscopic, or undergoes chemical decomposition. • Used for drying **Hormones, Vaccines, Vitamins, Gelatin, Dextran, Milk,** Plasma, Penicillin, and **Dextran.** • Antibiotics are preferably dried by a spray dryer. • The drying process used in the preparation of **smallpox vaccine** is spray drying.
Fluidised bed dryer (FBD)	Fluidised bed dryer	• Used for drying of granules in the **production of tablets.** • The FBD can be used for three distinct operations: **mixing, granulation, and drying.** • A fluidized bed dryer is significantly faster than a tray dryer, approximately **15 times** faster.
Vacuum dryer	-	• Ideal for **heat-sensitive materials** which undergo decomposition. • Commonly used in the pharma industry for drying **soft gelatin capsules.** • Suitable for drying **dusty and hygroscopic material.** • The **Vacuum dryer** is the preferred choice when the solvent needs to be recovered.
Freeze dryer (Lyophilization)	-	• **Lyophilisation** is another name for **Freeze drying.** It is a method of **drying**. • The process is based on the principle of sublimation, where water is removed from the frozen state directly to a vapor. • Involves **pre-freezing** to solidify water, followed by **sublimation** under vacuum. • Used for **blood plasma** and its fractionated products like blood serum preparations. Widely used for drying biological products such as **Bacteria, Viral Vaccine, Human Tissue, Antibiotics, Plant Extracts, Steroids, Vitamins, and Enzymes.** • **Decomposition of the product is minimized.** • The final product is **amorphous and readily soluble.** • It is highly useful for **thermolabile substances.** • It is important to note that freeze-drying is **NOT a very fast process.**

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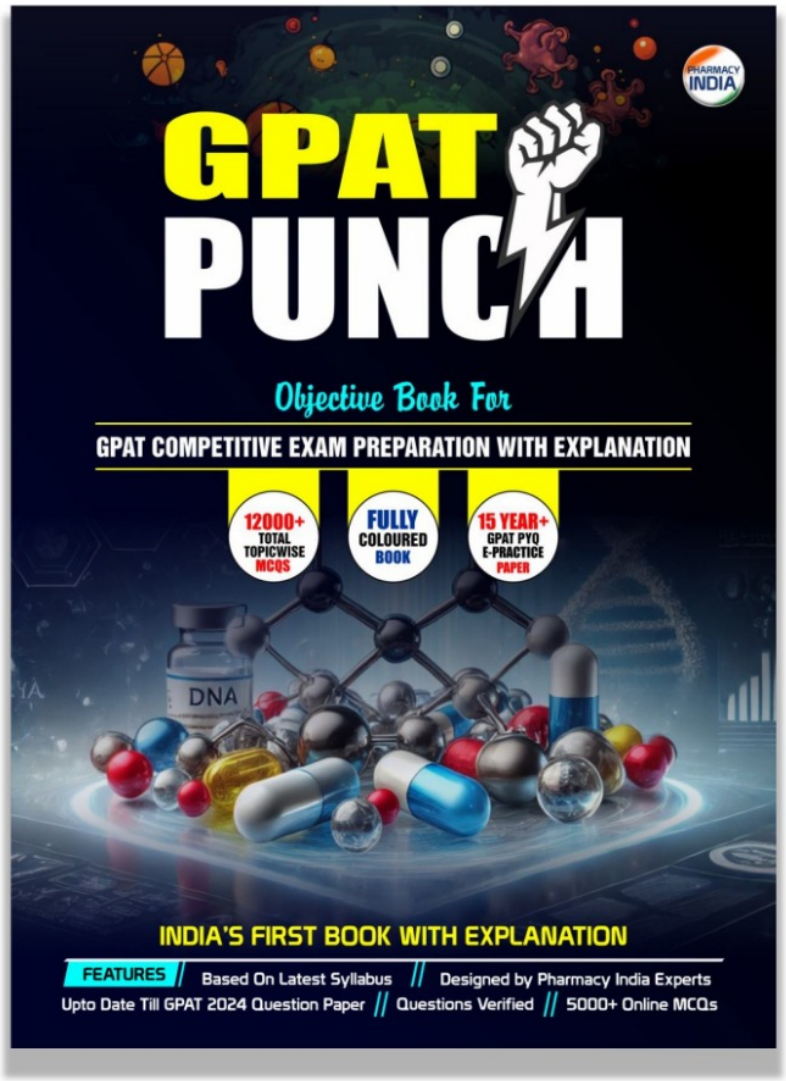

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