

GPAT

2027-28



PHARMACEUTICS

CLASS- 15



TIME- 8 : 30 P.M

BIPHASIC LIQUIDS DOSAGE FORM

UPDATED QUESTIONS TILL GPAT 2026

GPAT



VIDEO
LECTURE



PDF



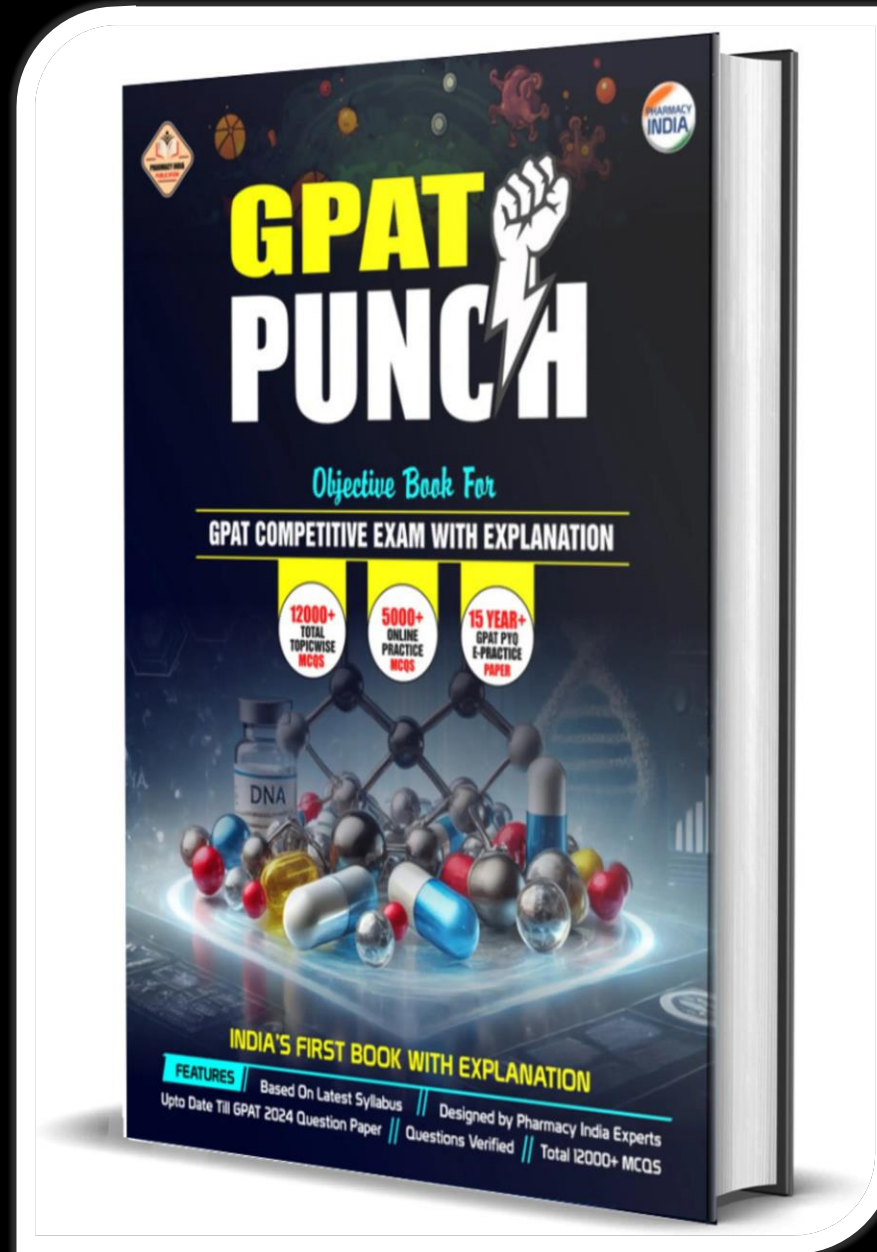
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COMMON DATA FOR QUESTION (01-03)

In a formulation development laboratory, you have to formulate an oral dosage form containing olive oil, Vitamin A and water



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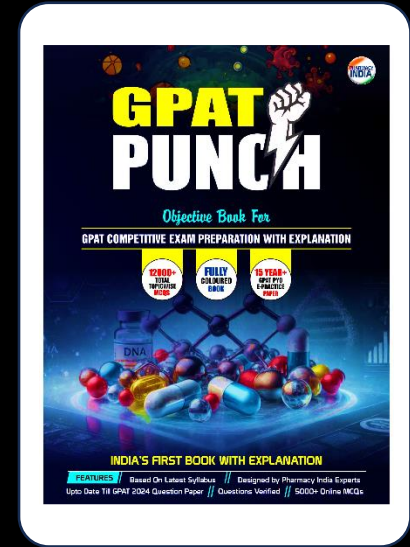


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01.

Suggest a suitable dosage form [GATE – 2003]

- (a) Solution
- (b) Suspension
- (c) Emulsion
- (d) Capsule



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01.

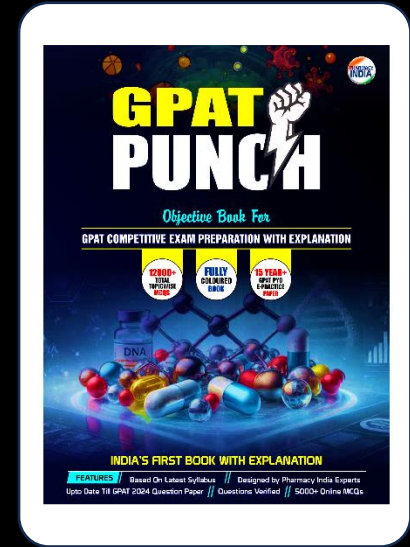
Suggest a suitable dosage form [GATE – 2003]

(a) Solution

(b) Suspension

(c) Emulsion

(d) Capsule



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EMULSION – THE IDEAL ORAL DOSAGE FORM

Formulation containing **OLIVE OIL**, **VITAMIN A** and **WATER**



OLIVE OIL

- Lipid (oil) phase
- Contains fat-soluble components
- Immiscible with water



VITAMIN A

- Fat-soluble (lipophilic)
- Dissolves in olive oil
- Cannot dissolve in water



WATER

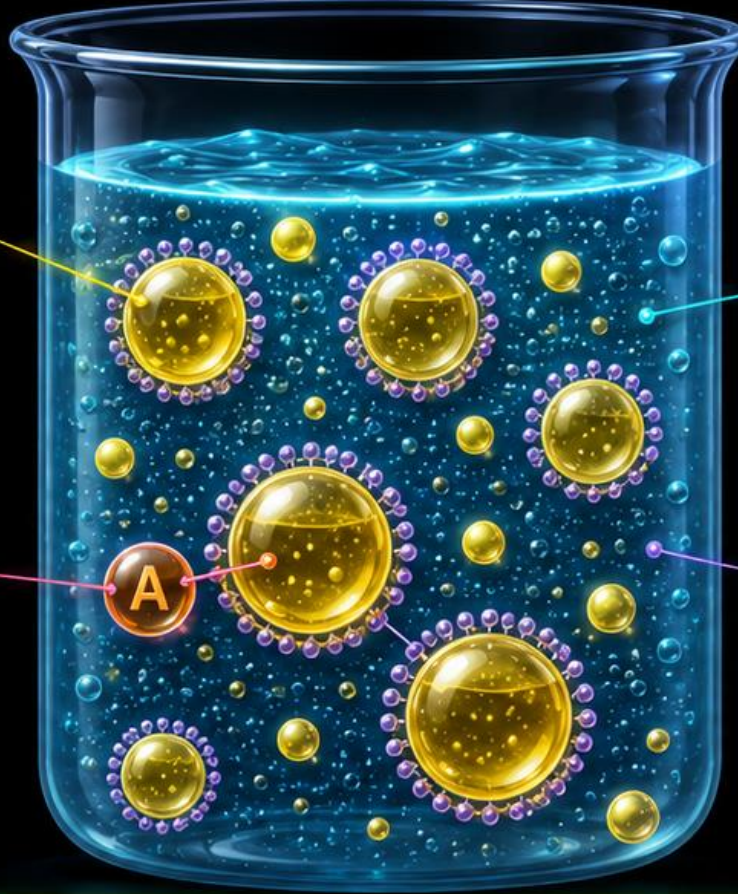
- Aqueous phase
- Immiscible with olive oil
- External continuous phase in O/W emulsion

OIL DROPLET

(Olive Oil + Vitamin A)

VITAMIN A (LIPOPHILIC)

Dissolved in oil droplets



WATER PHASE

External continuous phase

EMULSIFIER

Surrounds oil droplets and stabilizes the emulsion



IMMISCIBLE

Olive oil and water are immiscible and form separate phases.



EMULSION CONCEPT

Oral emulsion disperses oil droplets uniformly in water to deliver lipophilic drugs.



BENEFITS (O/W EMULSION)

- Improves dose uniformity
- Enhances palatability and patient compliance
- Better absorption of lipophilic vitamin A



EMULSIFIER – KEY TO STABILITY

- Lowers interfacial tension
- Forms a protective film around oil droplets
- Prevents coalescence and phase separation

TYPE: OIL-IN-WATER (O/W) EMULSION

Oil (olive oil) dispersed in water



DOSAGE FORM EXAMPLES

Oral emulsion, Emulsion in soft gelatin capsules, Self-emulsifying systems



GOAL

Deliver vitamin A effectively in a stable and palatable form.

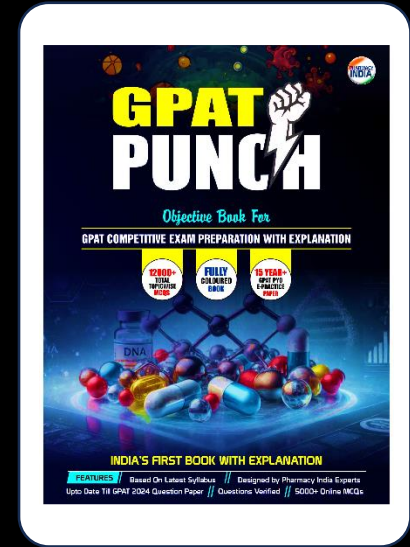


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02.

Suggest a substance to be incorporated into the formulation [GATE-2003]

- (a) Glycerin
- (b) Acacia
- (c) Cetrimide
- (d) Alcohol



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02.

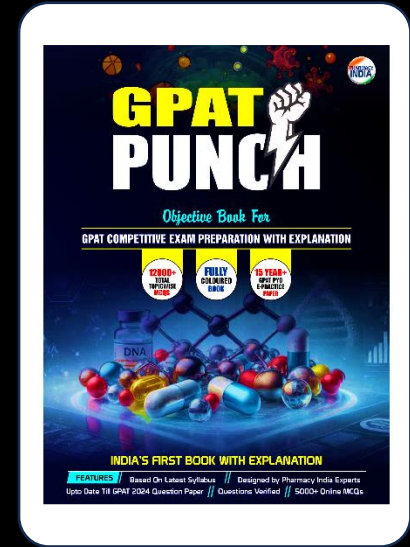
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(d) Alcohol



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ACACIA AS AN EMULSIFYING AGENT

In Olive Oil, Vitamin A & Water Formulation



NATURAL GUM EMULSIFIER

- Acacia (Acacia senegal) is a natural, non-toxic gum.
- Composed of complex arabinogalactan polysaccharides.
- Approved for pharmaceutical and food use.



PROTECTIVE FILM

- Acacia adsorbs at the oil–water interface.
- Forms a strong, hydrated film around oil droplets.
- Provides steric barrier and interfacial protection.



LOWERS INTERFACIAL TENSION

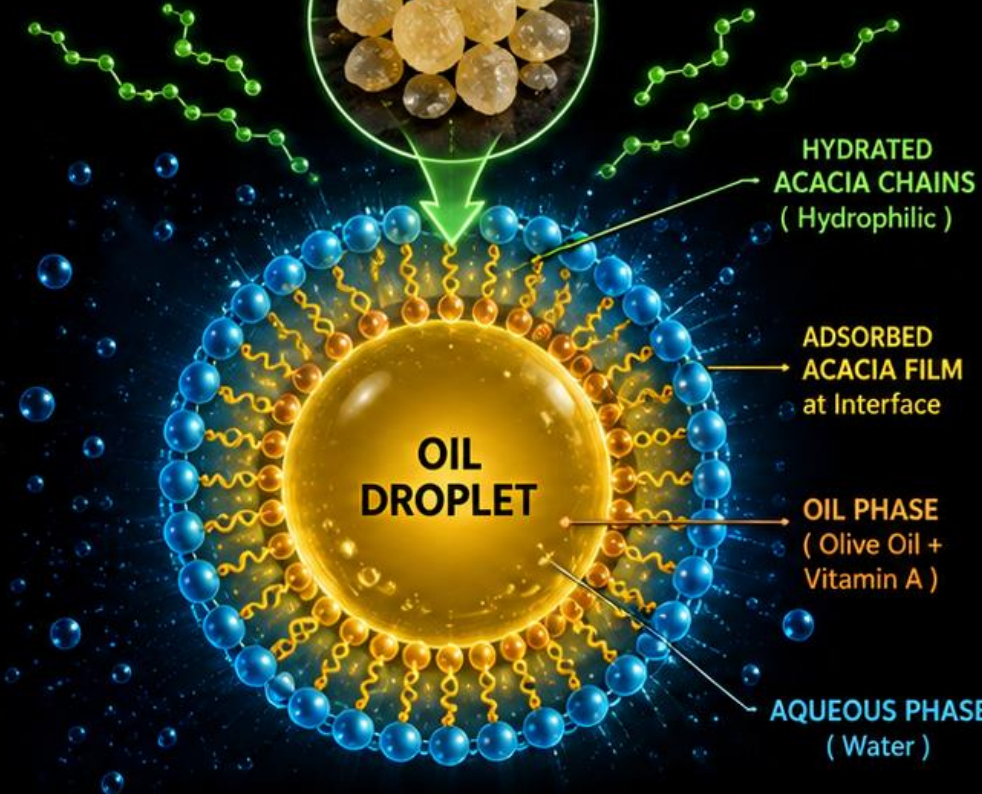
- Reduces oil–water interfacial tension.
- Facilitates formation of fine droplets.
- Stabilizes a stable O/W emulsion.



IMPROVES VISCOSITY & DISPERSION

- Increases viscosity of the continuous aqueous phase.
- Enhances uniform dispersion of oil droplets.
- Improves mouthfeel and physical stability.

ACACIA GUM



OIL IN WATER (O/W) EMULSION



Olive Oil
(Oil Phase)



Vitamin A
(Lipophilic Active)



Water
(Aqueous Phase)



Acacia Gum
(Emulsifier)



Protective Film
(Steric Stabilization)



PREVENTS DROPLET COALESCENCE & SEPARATION

- The protective film prevents droplets from coming together.
- Minimizes coalescence, creaming and phase separation.
- Ensures long-term physical stability of the formulation.



COMPATIBLE WITH FORMULATION COMPONENTS

- Stable with olive oil, vitamin A and water.
- Does not react with vitamin A.
- Maintains efficacy and stability of actives.



KEY BENEFITS

- Natural, safe and biocompatible.
- Enhances stability, viscosity and dispersion.
- Improves texture, appearance and shelf life.



TYPICAL USE LEVEL

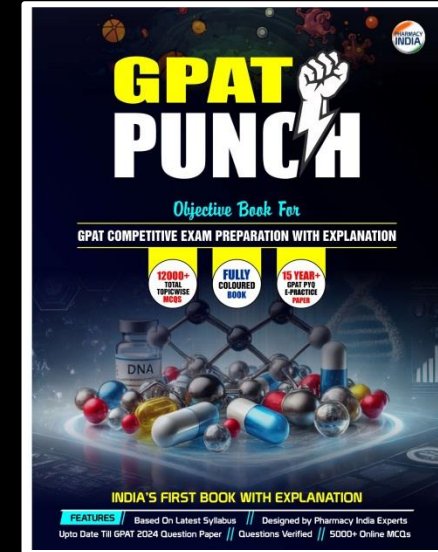
- 1–5% w/v (depending on desired viscosity and stability)
- Disperse in water with stirring to hydrate before emulsification.



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03. Select one of the appropriate labelling directions
[GATE-2003]

- (a) Keep in the refrigerator
- (b) No preservatives
- (c) Schedule 'G'
- (d) Shake well before use



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03. **Select one of the appropriate labelling directions**

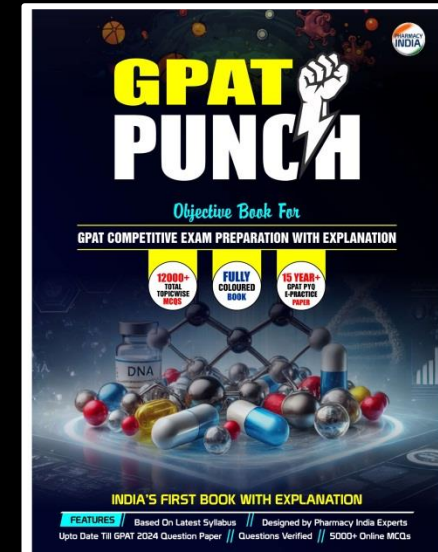
[GATE-2003]

(a) Keep in the refrigerator

(b) No preservatives

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(d) Shake well before use



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SHAKE WELL BEFORE USE

Proper Label Direction for Emulsions



EMULSIONS MAY CREAM OR SEPARATE ON STANDING

- Dispersed droplets rise or settle, causing phase separation.



SHAKING REDISTRIBUTES DROPLETS UNIFORMLY

- Restores even dispersion throughout the liquid.



ENSURES ACCURATE DOSE WITH EACH USE

- Prevents dose variation due to creaming or settling.



RESTORES TEMPORARY HOMOGENEITY

- Shaking brings back uniform consistency before dosing.



KEY AUXILIARY LABEL

- "Shake Well Before Use" is essential for all dispersed liquid dosage forms.



SHAKING REDISTRIBUTES
DISPERSED DROPLETS
UNIFORMLY

WHY IT MATTERS



Guarantees therapeutic efficacy and safety.



Prevents underdose or overdose.



Maintains physical stability during use.



Improves patient compliance and treatment outcome.



Standard requirement in labeling of emulsions and suspensions.

APPLIES TO



EMULSIONS



SUSPENSIONS



ORAL
DROPS



SYRUPS



ALWAYS SHAKE WELL BEFORE USE TO ENSURE UNIFORMITY, ACCURACY AND EFFECTIVENESS.



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04.

The degree of flocculation of a suspension is 1.5 and the sedimentation volume is 0.75. What will be the ultimate volume of deflocculated suspension? [GPAT-2011]

- (a) 2.0
- (b) 1.5
- (c) 0.75
- (d) 0.5



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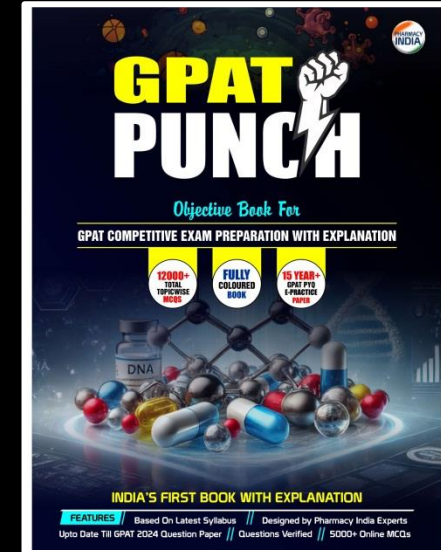


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- (b) 1.5
- (c) 0.75
- (d) 0.5



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CALCULATING THE ULTIMATE VOLUME OF A DEFLOCCULATED SUSPENSION



SUSPENSION

- Heterogeneous system of insoluble solid particles dispersed in a liquid medium.



FLOCCULATION

- Particles form loose aggregates (flocs), trapping more liquid and increasing volume.



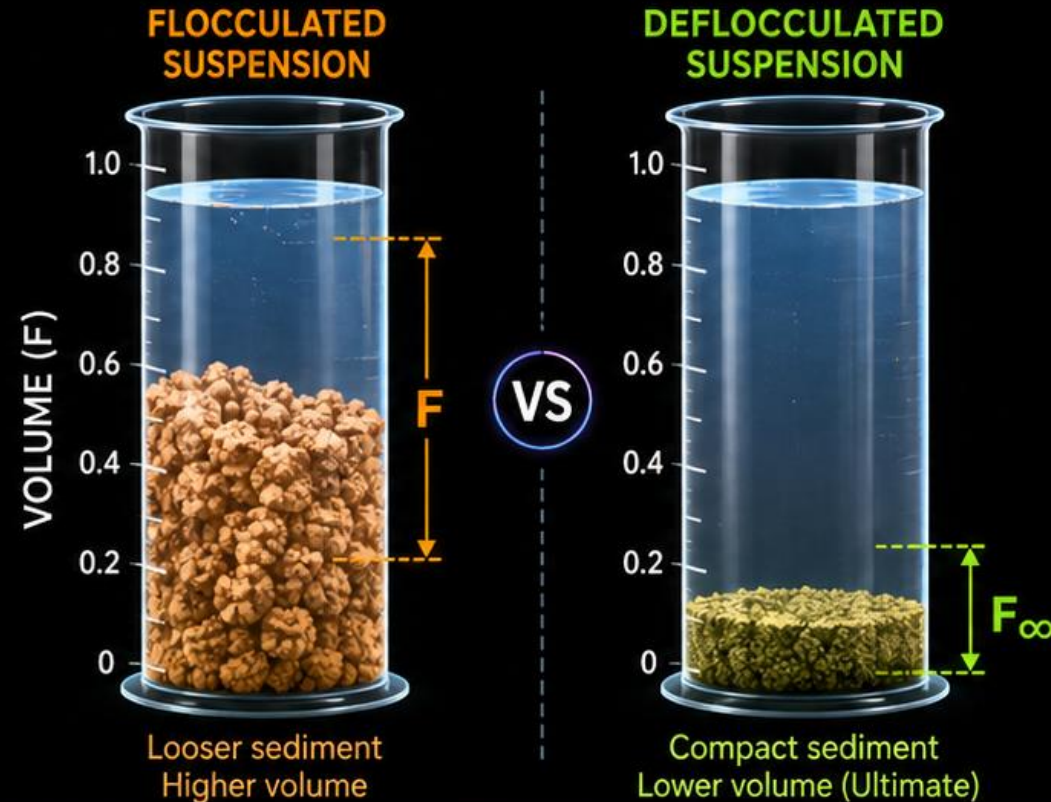
DEFLOCCULATION

- Particles exist as individual units, sedimenting more closely with less liquid.



SIGNIFICANCE

- Helps in predicting final sediment volume and ensures uniform dose on redispersion.



FORMULA

$$\text{Degree of flocculation, } \beta = \frac{F}{F_{\infty}}$$

F = Volume of flocculated suspension

F_∞ = Ultimate volume of deflocculated suspension

β = Degree of flocculation (dimensionless)



DEGREE OF FLOCCULATION

$$\beta = F / F_{\infty}$$



GIVEN

- F** (volume of flocculated suspension) = **0.75**
- β** (degree of flocculation) = **1.5**



CALCULATION

$$F_{\infty} = \frac{F}{\beta} = \frac{0.75}{1.5} = 0.5$$



RESULT

The ultimate sedimentation volume of the deflocculated suspension is **0.5**.



KEY POINT

A lower **F_∞** indicates a more compact sediment.



Accurate calculation of **F_∞** is essential for formulation design, quality control, and consistent therapeutic performance.



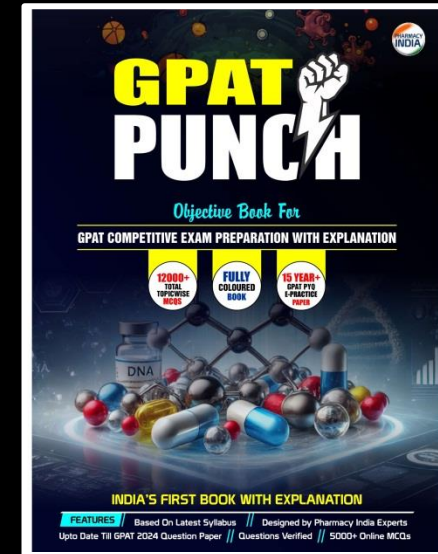
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05.

The stability and shelf life of a suspension determined by
[GPAT-2016]

- (a) Freeze-thaw studies
- (b) Sedimentation
- (c) Particle size
- (d) Particle shape



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05.

The stability and shelf life of a suspension determined by

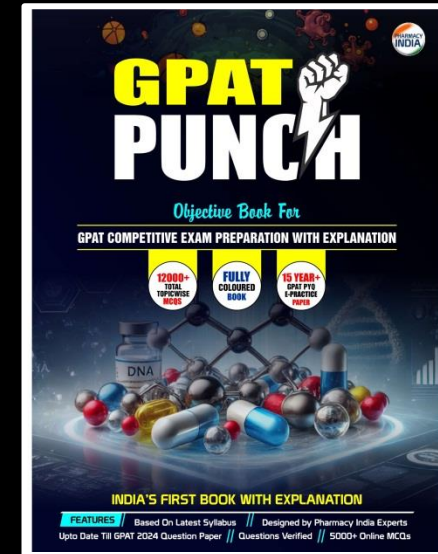
[GPAT-2016]

(a) Freeze-thaw studies

(b) Sedimentation

(c) Particle size

(d) Particle shape



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FREEZE-THAW STABILITY TEST

AN ACCELERATED STUDY TO PREDICT STABILITY & SHELF LIFE OF SUSPENSIONS

REPEATED COOLING & WARMING



- Repeated temperature cycling stresses the suspension.
- Mimics temperature fluctuations during storage & transport.

REVEALS PHYSICAL INSTABILITY



- Detects caking, aggregation, crystal growth or phase separation.
- Early warning of irreversible changes.

ACCELERATED PHYSICAL STUDY



- Uses temperature stress to accelerate physical degradation.
- Faster results vs. normal shelf-life studies.



PREDICTS STABILITY & SHELF LIFE



- Helps predict long-term physical stability during formulation development.
- Guides packaging and storage condition decisions.

STABLE SUSPENSION RESISTS CHANGE



- A stable product shows minimal or no irreversible change after cycles.
- Maintains original appearance, redispersibility & properties.

EVALUATION PARAMETERS



- Appearance & phase separation
- Redispersibility
- Sedimentation volume
- Particle size distribution
- pH & viscosity
- Assay / content uniformity



GOAL: Ensure the suspension remains physically stable and effective throughout its intended shelf life.



Protect
Quality



Ensure
Safety



Deliver
Efficacy



Assure
Shelf Life



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06.

Aggregates which are characterized by fibrous & open network have

[GPAT-2015]

[P] Called as floccules

[Q] Have high sedimentation height

[R] Have high sedimentation rate

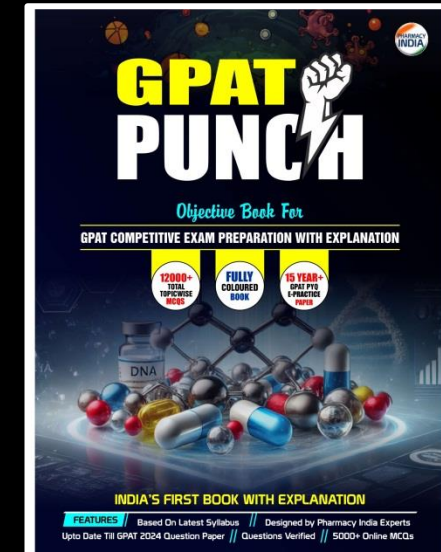
[S] Called as coagules

(a) [P] & [Q]

(b) [P], [Q] & [R]

(c) [Q] & [S]

(d) [Q], [R] & [S]



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06.

Aggregates which are characterized by fibrous & open network have

[GPAT-2015]

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[Q] Have high sedimentation height

[R] Have high sedimentation rate

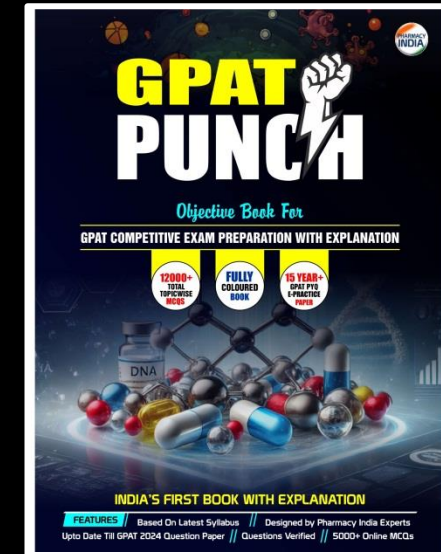
[S] Called as coagules

(a) [P] & [Q]

(b) [P], [Q] & [R]

(c) [Q] & [S]

(d) [Q], [R] & [S]



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FLOCCULES IN SUSPENSIONS

— AGGREGATES WITH A FIBROUS OPEN NETWORK —



LOOSE AGGREGATES

Loose aggregates of particles held together by weak forces are called **floccules**.



OPEN FIBROUS NETWORK

Particles link in a three-dimensional, **open and fibrous network**, trapping the medium (liquid).



RAPID SETTLING

Because particles link together, the effective particle size increases and they **settle rapidly**.



HIGH SEDIMENTATION

Floccules occupy a large volume in the sediment, giving **high sedimentation volume or height**.

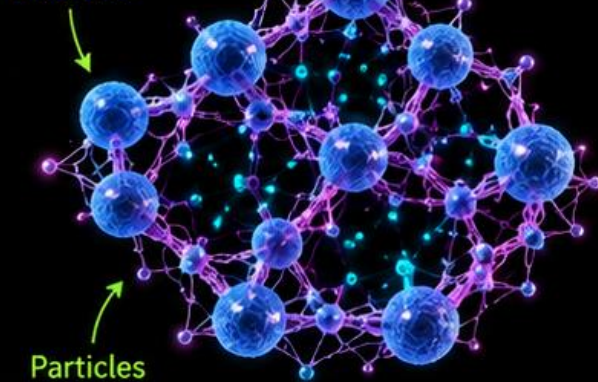


EASY REDISPERSION

The loose, open structure breaks easily on gentle agitation. Sediment is **easily redispersed**.

WITH FLOCCULATION

Open fibrous network



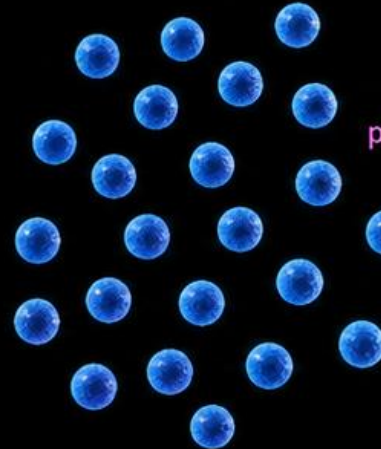
Particles linked in floccules

High sedimentation height / volume



WITHOUT FLOCCULATION

Free particles



Low sedimentation height / volume



NATURE OF BONDING

- Weak, non-valent forces
- Van der Waals forces
- Electrostatic interactions
- Bridging by polymers



CHARACTERISTICS

- Open, porous structure
- Traps the liquid within
- Large effective size
- Settles as a loose mass



IMPORTANCE

- Promotes faster clarification
- Forms bulkier, voluminous sediment
- Preferred in many pharmaceutical suspensions



DESIRABLE IN FORMULATIONS

- Improves settling rate
- Produces a loose sediment
- Allows easy redispersion with gentle shaking



EASY REDISPERSION

Gentle agitation breaks the open network, freeing particles for uniform redispersion.



Floccules are loose aggregates forming an **open fibrous network** that **settle rapidly**, occupy a **large sediment volume**, and are **easily redispersed** with minimal agitation.



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07.

The following prescription is given to the pharmacist by the physician to dispense

Rx

Calciferol solution

0.3 ml

Water to Q.S

5.0 ml send 25 ml

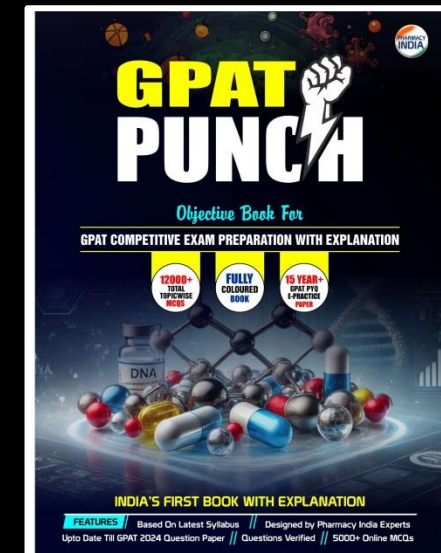
Final dosage form of this prescription will be [GPAT – 2000]

(a) Solution

(b) Elixir

(c) Emulsion

(d) Suspension



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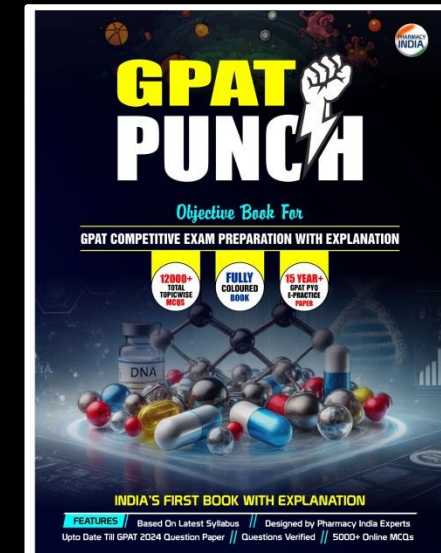
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CALCIFEROL EMULSION

FROM OILY SOLUTION + WATER TO A STABLE ORAL EMULSION



CALCIFEROL

- Fat-soluble vitamin D₃
- Poorly soluble in water
- Present in an oily solution



WATER (AQUEOUS PHASE)

- Acts as the aqueous vehicle
- Helps in forming the dispersed phase
- Provides bulk and palatability



OIL (OILY PHASE)

- Calciferol is dissolved in oil
- Oil serves as the continuous phase before emulsification
- Example oils: Olive oil, Soybean oil, Peanut oil

PRESCRIPTION



BIPHASIC SYSTEM (OIL + WATER)



Oil and water form a biphasic system.



EMULSIFIER
(e.g., Gum Acacia, Tween 80, Span 80)



EMULSION (FINAL DOSAGE FORM)



With an emulsifier, the final dosage form becomes an emulsion.



EMULSION FORMATION

- Emulsifier reduces interfacial tension between oil and water
- Disperses oil droplets in water
- Forms Oil-in-Water (O/W) emulsion suitable for oral use



EMULSIFIER (KEY ROLE)

- Stabilizes the emulsion
- Prevents coalescence of oil droplets
- Ensures physical stability and shelf life



BENEFITS

- Better uniformity of the dose
- Improved palatability
- Enhanced absorption of fat-soluble calciferol
- Patient compliance

KEY TAKEAWAYS



Calciferol is fat-soluble and present in oil.



Water acts as the aqueous vehicle.



Oil and water form a biphasic system.



With an emulsifier, the system becomes an emulsion.



Emulsification ensures better uniformity of the dose.



08.

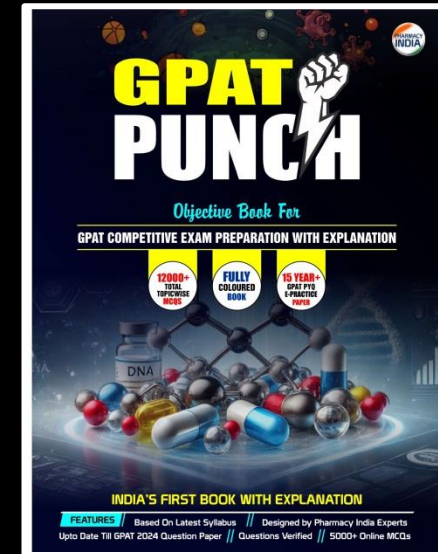
To determine the effect of breath holding on the deposition of particles, the sedimentation efficiency, S , is defined as [GPAT – 2021]

(a) $S = (\text{Distance of the particle falls during breath holding}) \div (\text{Mean regional airway diameter})$

(b) $S = (\text{Distance of the particle falls during breath holding}) \times (\text{Half the mean regional airway diameter})$

(c) $S = (\text{Distance of the particle falls during breath holding}) + (\text{Twice mean regional airway diameter})$

(d) $S = (\text{Distance of the particle falls during breath holding}) (\text{Mean regional airway diameter})$



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08.

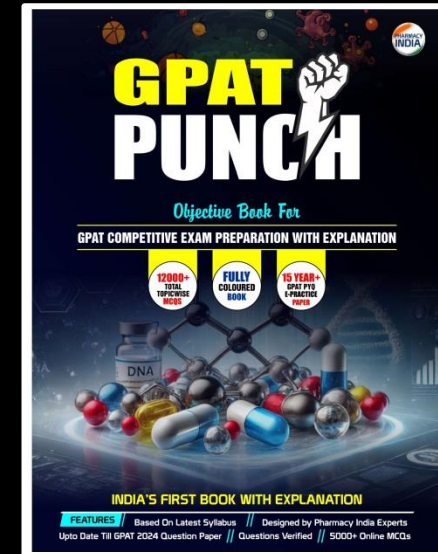
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SEDIMENTATION EFFICIENCY IN PULMONARY PARTICLE DEPOSITION DURING BREATH HOLDING



BREATH HOLDING EFFECT

- Breath holding increases the time available for gravitational settling.
- Longer residence time enhances particle deposition in the airways.



GREATER SETTLING, BETTER DEPOSITION

- More sedimentation leads to higher regional deposition.
- Enhances delivery to peripheral airways and alveolar region.



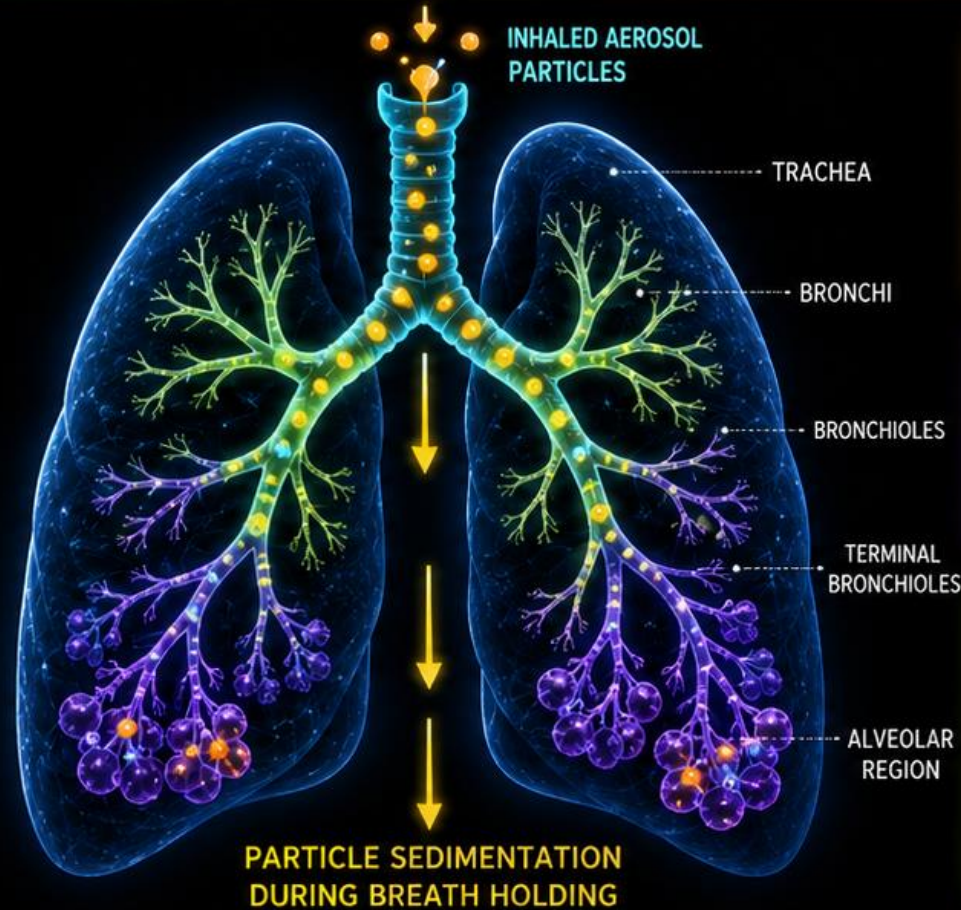
KEY DETERMINANT

- Sedimentation efficiency depends on the distance a particle falls during breath holding.
- Greater fall distance → greater chance of deposition.



CLINICAL SIGNIFICANCE

- Helps in optimizing inhalation technique and breath hold time.
- Important for effective delivery of aerosols to deep lungs.



WHAT IS SEDIMENTATION?

- Deposition of particles due to gravity when airflow velocity is low or zero.
- Dominant mechanism in small airways and alveolar region during breath holding.



SEDIMENTATION EFFICIENCY RELATION

- Depends on the distance a particle falls during breath holding.
- Relation used to estimate deposition in airways:

SEDIMENTATION DISTANCE (S)

$$S = (V_g \times t_h) + d_{\text{airway}}$$

Where,

V_g = Gravitational settling velocity of the particle

t_h = Breath holding time

d_{airway} = Mean regional airway diameter



WHY IT MATTERS

- This concept helps predict and understand aerosol deposition in different lung regions.
- Essential in inhaler design, therapy optimization and lung-targeted drug delivery.

PARTICLE SIZE & DEPOSITION TENDENCY


< 1 μm
Diffusion
dominant


1–5 μm
Optimal
deposition


5–10 μm
Sedimentation
dominant


> 10 μm
Impaction
dominant

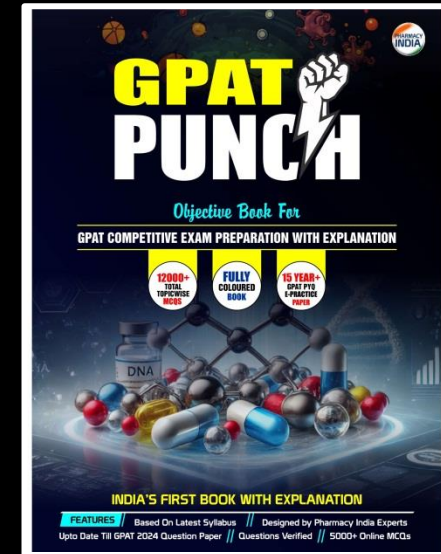


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09.

O/W microemulsion containing hydrophilic surfactant produces [GATE-1994]

- (a) Translucent emulsion
- (b) Transparent emulsion
- (c) Milky white emulsion
- (d) Intense white emulsion



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09.

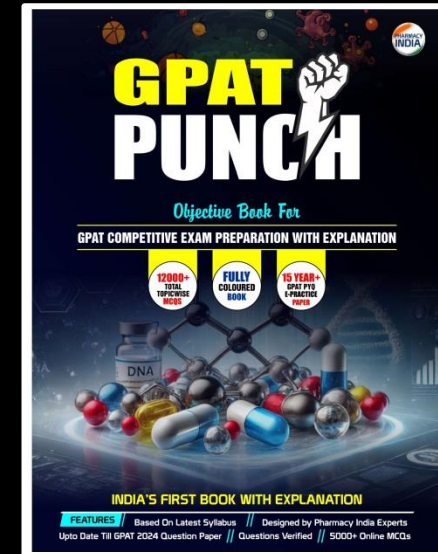
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TRANSPARENT OIL-IN-WATER MICROEMULSION

• WITH HYDROPHILIC SURFACTANT •



1. HYDROPHILIC SURFACTANT

- High HLB surfactant
- Strongly interacts with water
- Lowers interfacial tension
- Favors an O/W system



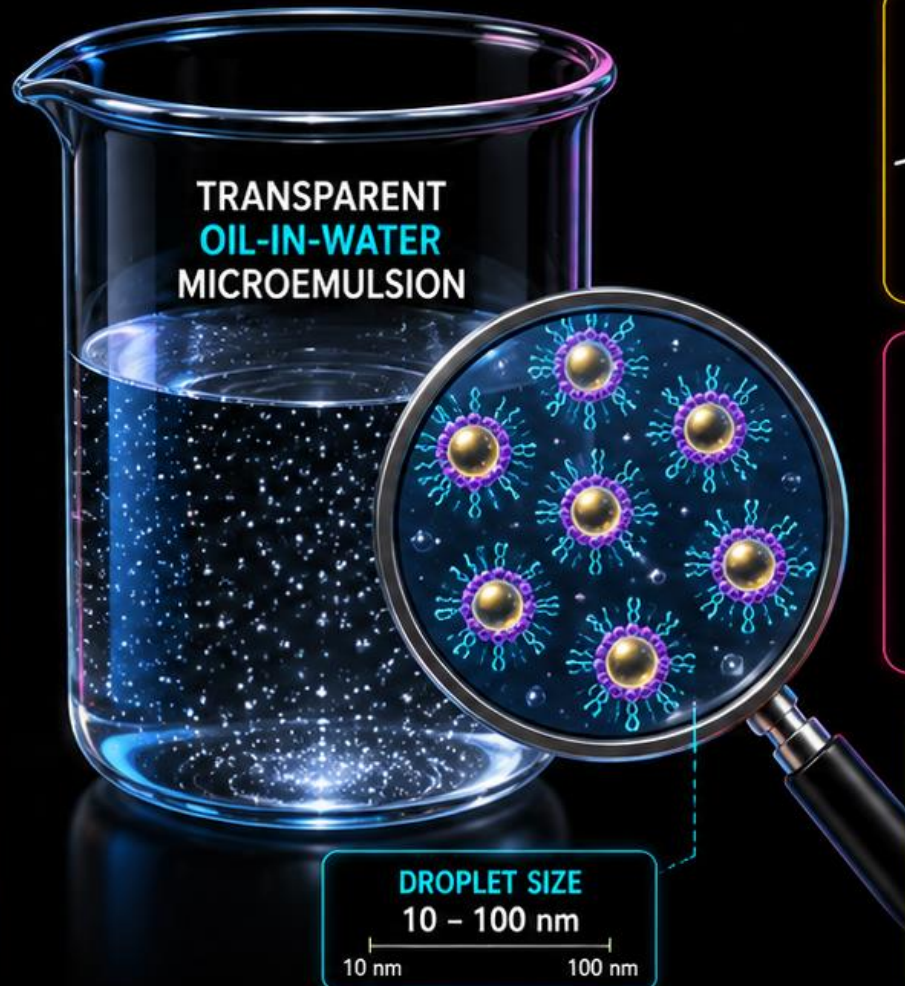
2. OIL-IN-WATER (O/W) SYSTEM

- Oil is dispersed as tiny droplets in continuous water
- Surfactant forms a protective interfacial film
- Thermodynamically stable and isotropic



3. EXTREMELY SMALL DROPLETS

- Droplet size typically **10–100 nm**
- Very large interfacial area
- High kinetic stability



4. MINIMAL LIGHT SCATTERING

- Droplet size $\ll$ wavelength of visible light (400–700 nm)
- Negligible light scattering
- System remains clear



5. TRANSPARENT APPEARANCE

- No turbidity or cloudiness
- Optically clear and colorless
- Indicates microemulsion formation



6. KEY ADVANTAGES

- Thermodynamically stable
- Isotropic single phase
- Self-forming and spontaneous
- High solubilization capacity
- Improved bioavailability

COMPONENTS



OIL



HYDROPHILIC
SURFACTANT



WATER



CO-SURFACTANT



MICROEMULSIONS ARE
THERMODYNAMICALLY STABLE,
ISOTROPIC, AND TRANSPARENT
WHEN O/W SYSTEM IS FORMED.



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10.

Theories of emulsification are characterized by one of the following EXCEPT [GPAT-2019]

- (a) Film formation
- (b) Phase inversion
- (c) Monomolecular adsorption
- (d) Solid particle adsorption



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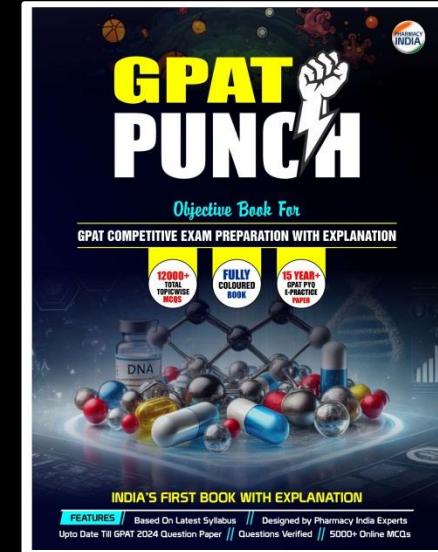
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Theories of emulsification are characterized by one of the following EXCEPT [GPAT-2019]

- (a) Film formation
- (b) Phase inversion
- (c) Monomolecular adsorption
- (d) Solid particle adsorption



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THEORIES OF EMULSIFICATION

HOW EMULSIONS ARE STABILIZED AT THE INTERFACE



CLASSICAL THEORIES OF EMULSIFICATION

- Explain stabilization of droplets at the interface.
- Focus on how a protective barrier prevents coalescence.



ROLE OF EMULSIFYING AGENTS

- Reduce interfacial tension (IFT) between oil and water.
- Form an interfacial film or barrier around droplets.



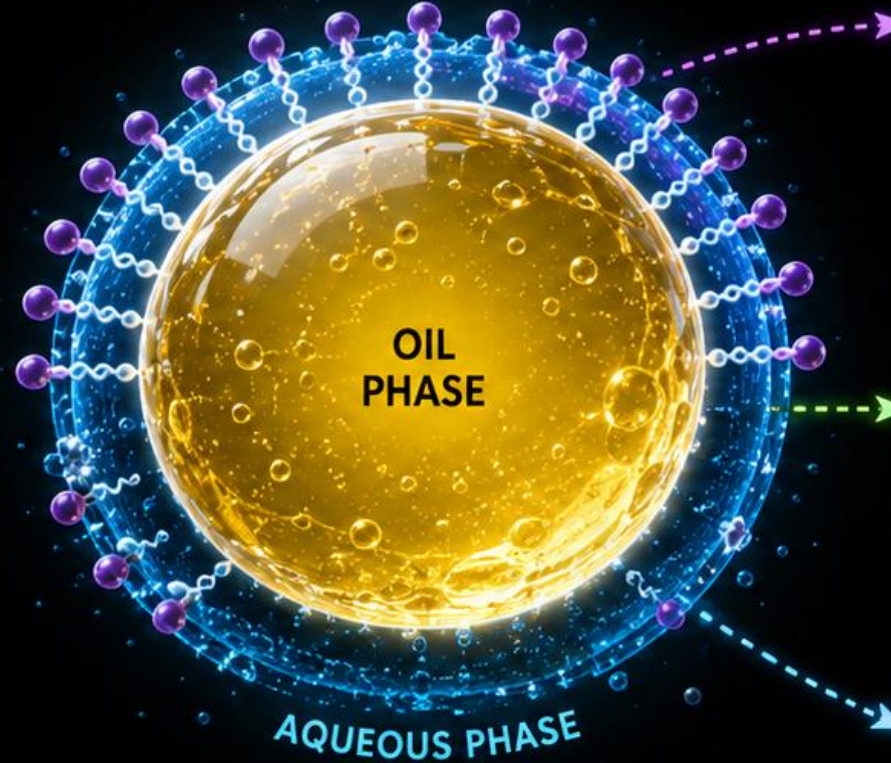
STABILIZATION OF EMULSIONS

- Interfacial film/particles create a mechanical barrier.
- Prevent droplet coalescence and flocculation.



KEY TAKEAWAY

- Theories describe mechanisms of stabilization, not the act of forming an emulsion.
- Many systems may follow one or more theories simultaneously.

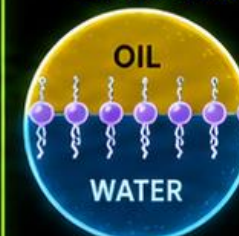


1. FILM FORMATION THEORY



- Emulsifying agent forms a continuous interfacial film around the droplet.
- Provides a mechanical barrier that prevents coalescence.

2. MONOMOLECULAR ADSORPTION THEORY



- Surfactant molecules adsorb at the interface as a monomolecular layer.
- Oriented with hydrophilic part in water and lipophilic part in oil.

3. SOLID PARTICLE ADSORPTION THEORY



- Finely divided solid particles adsorb irreversibly at the interface.
- Form a rigid interfacial layer that stabilizes the droplet (Pickering emulsions).



PHASE INVERSION – NOT A CLASSICAL THEORY

- Phase inversion is a phenomenon or technique, not a theory of emulsification.
- It refers to the change in type of emulsion (O/W ↔ W/O) by altering phase volume, emulsifier concentration, temperature, or salinity.



QUICK SUMMARY

- Film Formation – Continuous interfacial film
- Monomolecular Adsorption – Surfactant monolayer
- Solid Particle Adsorption – Particulate barrier
- All theories explain stabilization at the interface



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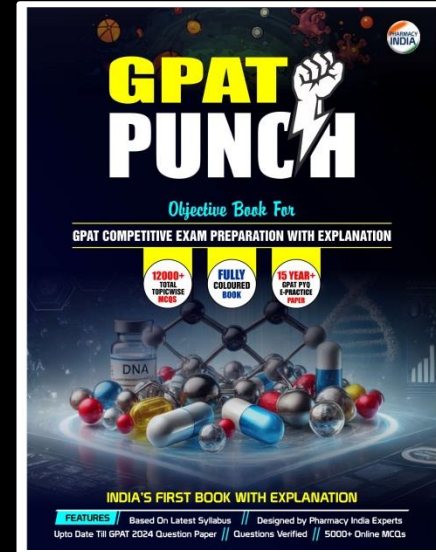


11.

Which phase of emulsion is reversible phase?

[GPAT-2015]

- (a) Cracking
- (b) Creaming
- (c) Phase inversion
- (d) Coalescence



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11.

Which phase of emulsion is reversible phase?

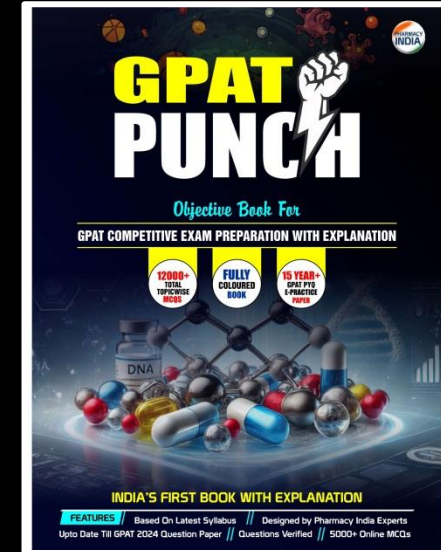
[GPAT-2015]

(a) Cracking

(b) Creaming

(c) Phase inversion

(d) Coalescence



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CREAMING IN EMULSIONS



1. CREAMING

Upward or downward movement of droplets due to density difference.



2. REVERSIBLE INSTABILITY

It is a reversible instability; droplets do not fuse.



SHAKE
TO
REDISPERSE



3. EASILY REDISPERSED

Redisperses easily on gentle shaking.

4. NOT SAME AS CRACKING OR COALESCENCE



Different from cracking or coalescence.



CONTROL BY



SMALL
GLOBULE SIZE



HIGHER
VISCOSITY



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12.

When ammonium chloride is gradually and slowly incorporated into an emulsion stabilized with ammonium oleate [GATE-2008]

- (a) Emulsion will crack immediately
- (b) It will invert from O/W to W/O type
- (c) It will invert from W/O to O/W type
- (d) There will be no impact on its physical stability



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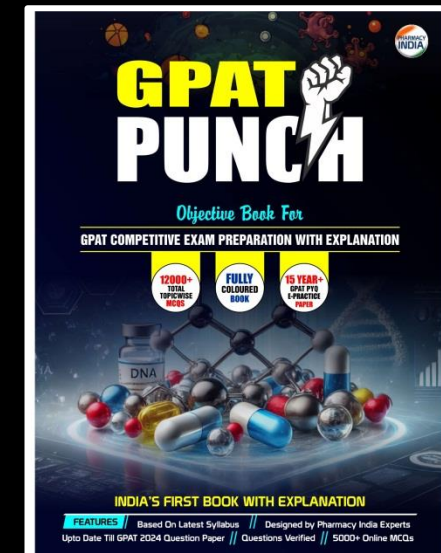
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- (c) It will invert from W/O to O/W type
- (d) There will be no impact on its physical stability



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PHASE INVERSION

BY ELECTROLYTE ADDITION

1



Ammonium **oleate** is a soap emulsifier that favors an **O/W** system.

2



Addition of **ammonium chloride** can alter emulsifier solubility.

3



The emulsion may invert so **the continuous phase changes**.

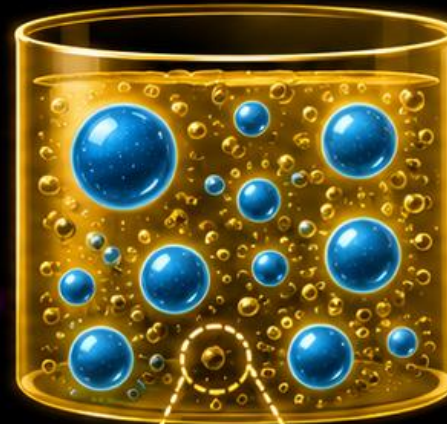
OIL-IN-WATER (O/W)
Oil droplets dispersed in water



AMMONIUM
CHLORIDE
ADDED



WATER-IN-OIL (W/O)
Water droplets dispersed in oil



4

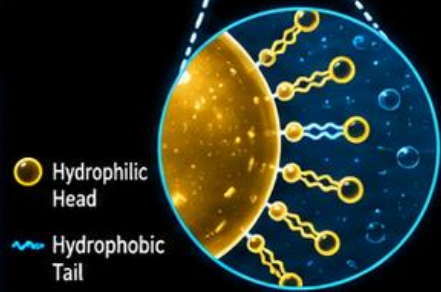


This phenomenon is called **phase inversion**.

5



Inversion changes the **properties and stability** of the emulsion.



SOAP EMULSIFIER
(AMMONIUM OLEATE)

● Water Droplet
● Oil (Continuous Phase)



ELECTROLYTES CAN TRIGGER EMULSION INVERSION





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13.

Globule size of parenteral emulsion should be [GPAT-2014]

- (a) 0.1 to 0.5 μm
- (b) 0.5 to 5 μm
- (c) 5 to 10 μm
- (d) None of these



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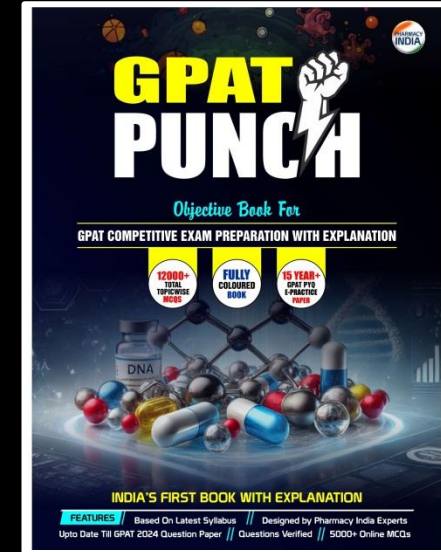


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- (a) 0.1 to 0.5 μm
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PARENTERAL EMULSION GLOBULE SIZE



RECOMMENDED
GLOBULE SIZE:
0.1 – 0.5 μm .



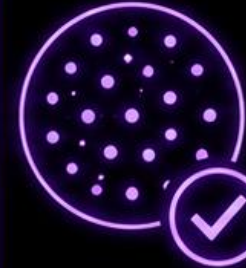
VERY FINE
DROPLETS ARE
ESSENTIAL
FOR SAFE PARENTERAL USE.



GLOBULE SIZE
0.1 – 0.5 μm
RECOMMENDED RANGE



SMALL SIZE
LOWERS THE
RISK OF
EMBOLISM.



UNIFORM SIZE
IMPROVES
STABILITY
AND SAFETY.



PARENTERAL EMULSIONS **MUST BE FINELY DISPERSED**



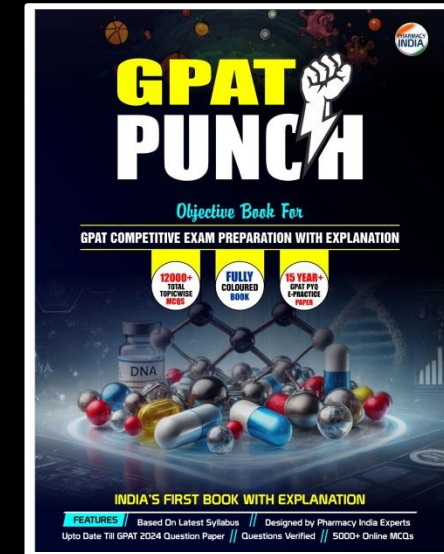


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14.

Which of the following equipment is based on the principle of Pohlman liquid whistle? [GPAT-2023 Shift-I]



- (a) Ultrasonifier
- (b) Mechanical stirrer
- (c) Silverson homogeniser
- (d) Colloid mill



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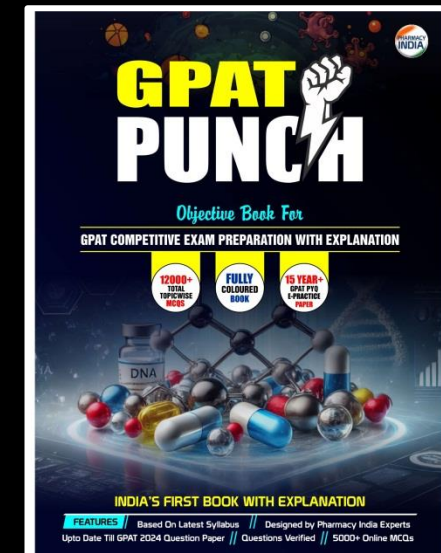
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- (a) Ultrasonifier
- (b) Mechanical stirrer
- (c) Silverson homogeniser
- (d) Colloid mill



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ULTRASONIFIER

— — Based on Pohlman liquid whistle principle — —



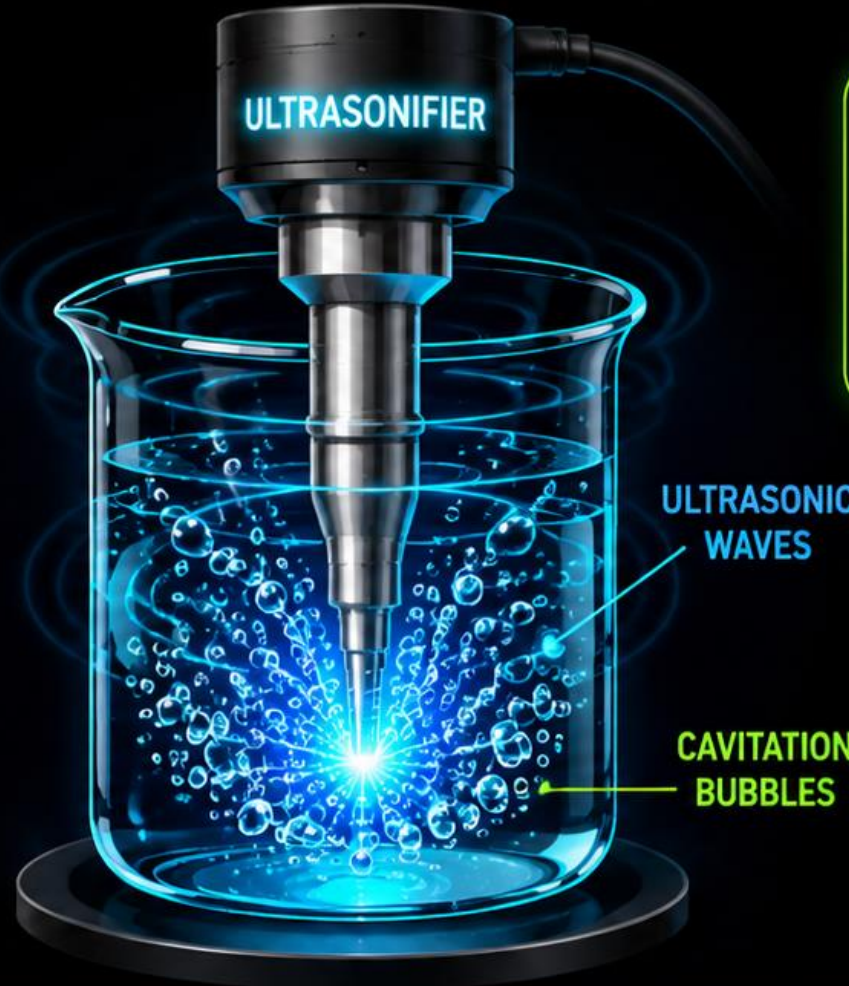
1. USES
ULTRASONIC
ENERGY TO
CREATE CAVITATION.



2. HIGH-FREQUENCY
WAVES BREAK
DROPLETS AND
PARTICLES.



3. PRODUCES
FINE EMULSIONS
AND DISPERSIONS.



4. GIVES
INTENSE
MIXING AND
SIZE REDUCTION.



5. USEFUL IN
HOMOGENIZATION
OF LIQUIDS.



KEY PRINCIPLE: ULTRASONIC CAVITATION

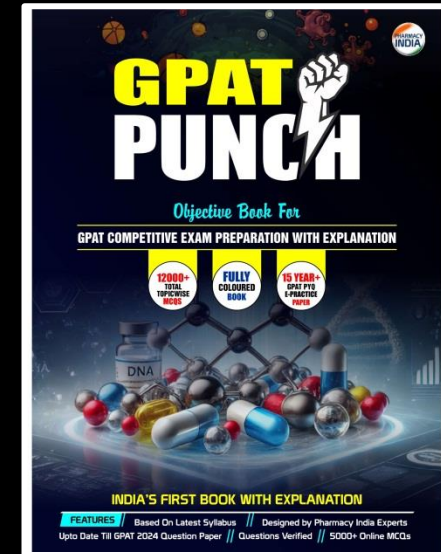




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15. Brownian movement of particle in suspension cause

- (a) Assist sedimentation
- (b) Promote sedimentation
- (c) Prevent sedimentation
- (d) Increase sedimentation rate



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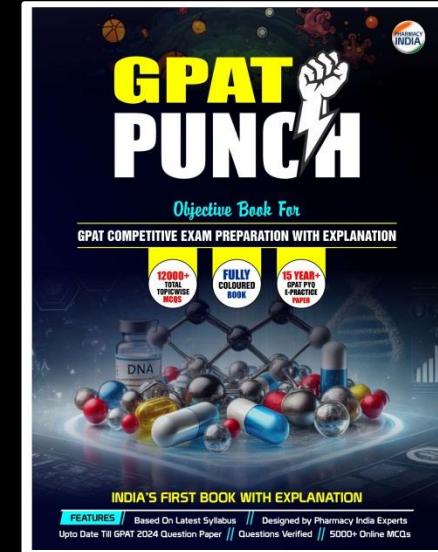


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15.

**Brownian movement of particle in suspension
cause**

- (a) Assist sedimentation
- (b) Promote sedimentation
- (c) Prevent sedimentation
- (d) Increase sedimentation rate



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BROWNIAN MOVEMENT IN SUSPENSIONS



1. RANDOM MOTION

Brownian movement is random motion of small particles.



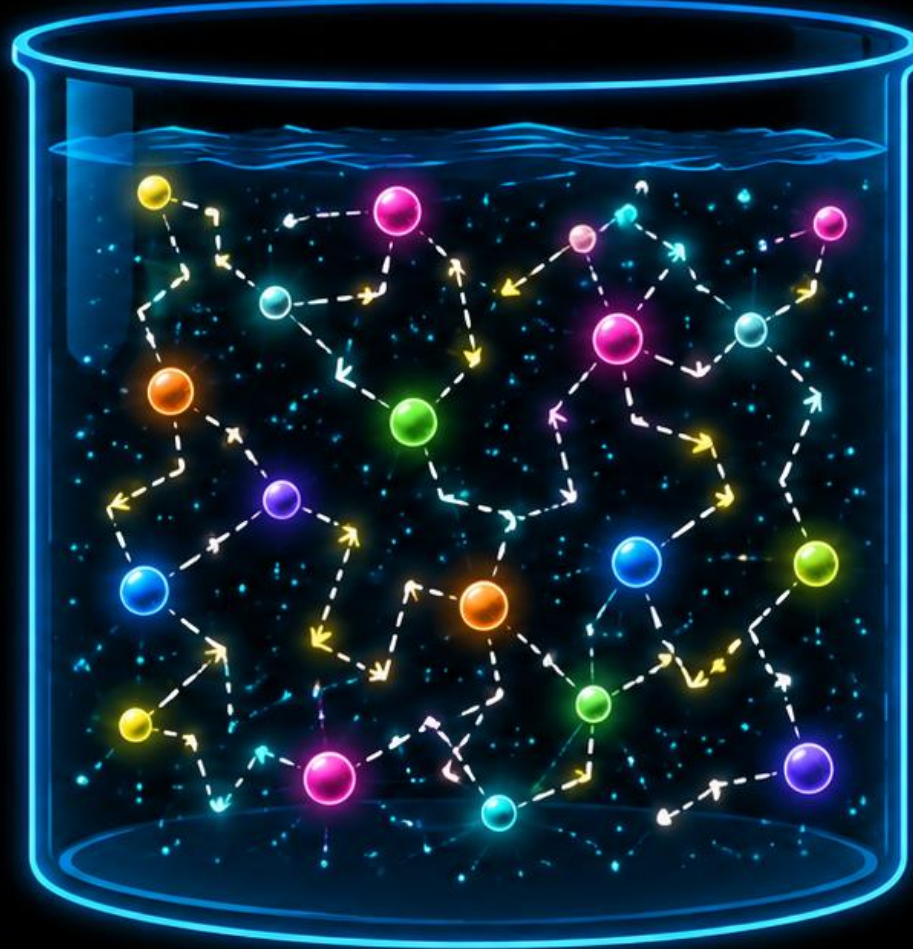
2. OPPOSES SETTLING

It opposes settling and helps keep particles suspended.



3. MORE IMPORTANT IN FINE PARTICLES

More important in very fine particles.



4. THERMAL ENERGY

Thermal energy causes continuous zig-zag motion.



5. REDUCES SEDIMENTATION

It reduces the tendency toward sedimentation.



Brownian motion helps prevent sedimentation



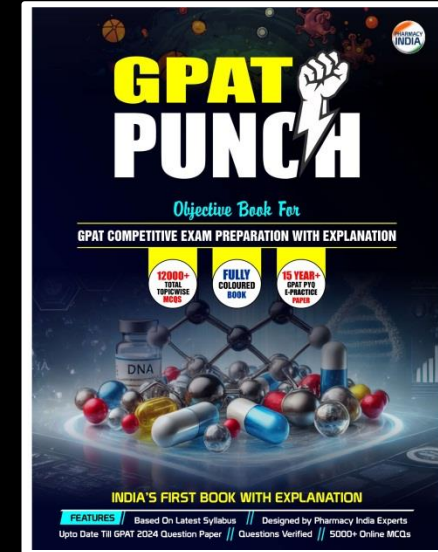
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16.

Pharmaceutical suspensions are generally

- (a) Flocculated
- (b) Deflocculated
- (c) Both (a) and (b)
- (d) None of the above



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16.

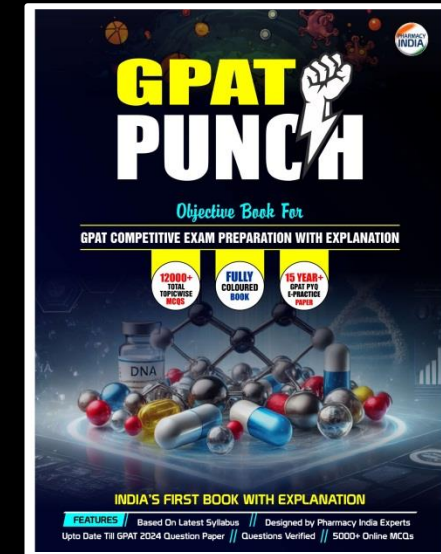
Pharmaceutical suspensions are generally

(a) Flocculated

(b) Deflocculated

(c) Both (a) and (b)

(d) None of the above



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FLOCCULATED PHARMACEUTICAL SUSPENSIONS

1



Most pharmaceutical suspensions are designed as **flocculated systems**.

2



Particles form loose aggregates called **flocs**.

AT REST



LOOSE FLOCS
THROUGHOUT

AFTER SETTLING



FLUFFY SEDIMENT
NO HARD CAKE

AFTER SHAKING



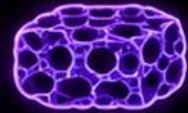
EASILY
REDISPERSED

3



Flocs settle faster but do not form a **hard cake**.

4



Sediment is **porous** and **easy to redisperse**.

5



This improves **dosing uniformity** after shaking.



CONTROLLED FLOCCULATION IS PREFERRED





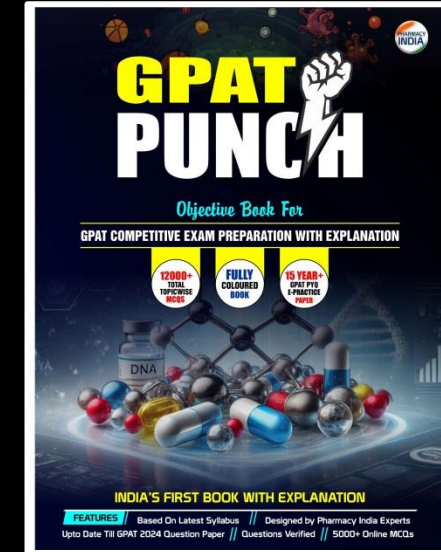
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17.

Rate of sedimentation is high in

- (a) Flocculated
- (b) Deflocculated
- (c) Both (a) and (b)
- (d) None of the above



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17.

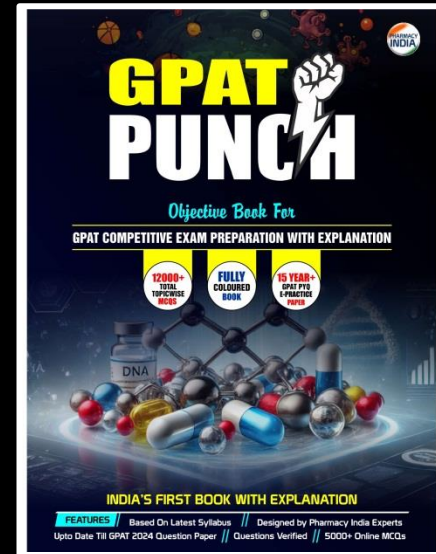
Rate of sedimentation is high in

(a) Flocculated

(b) Deflocculated

(c) Both (a) and (b)

(d) None of the above



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SEDIMENTATION RATE IN FLOCCULATED SYSTEMS



1 Sedimentation rate is higher in **flocculated** suspensions.



2 Flocs have **larger effective particle size**.



3 By Stokes' law, **larger particles settle faster**.



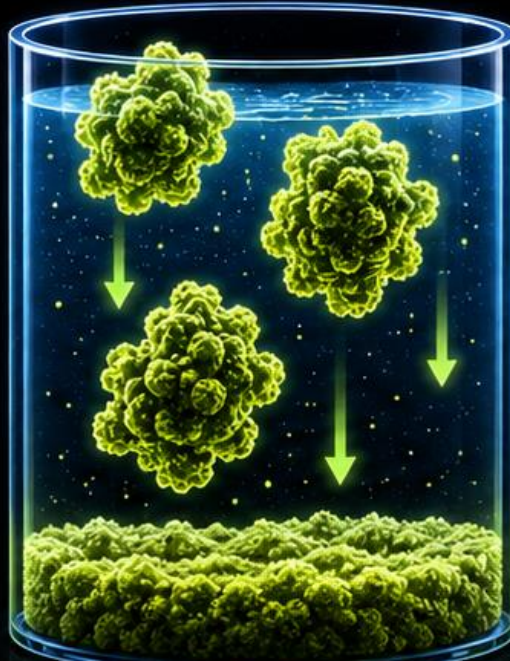
4 The resulting sediment remains **loose and easily redispersed**.



5 Deflocculated systems settle **slowly but may cake**.

FLOCCULATED SYSTEM

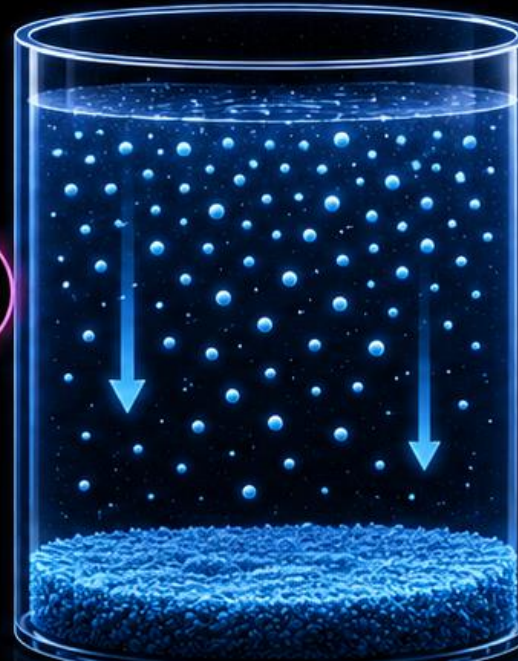
LARGE FLOCS



FAST SETTLING
LOOSE SEDIMENT

DEFLOCCULATED SYSTEM

SMALL INDIVIDUAL PARTICLES



SLOW SETTLING
COMPACT SEDIMENT (MAY CAKE)

VS



KEY TAKEAWAYS



HIGHER RATE
Flocculated systems settle much faster.



BIGGER EFFECTIVE SIZE
Flocs behave as larger particles.



STOKES' LAW
Larger size → higher settling velocity.



LOOSE & REDISPERSIBLE
Sediment is porous and easy to redisperse.



DEFLOCCULATED RISK
Slow settling and possible caking.



Flocculated systems **settle fast** but **redisperse well**





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18.

If particle size is $1\text{ }\mu\text{m}$ to $100\text{ }\mu\text{m}$ _____

- (a) Coarse dispersion
- (b) Colloidal dispersion
- (c) Flocculated
- (d) Deflocculated



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18.

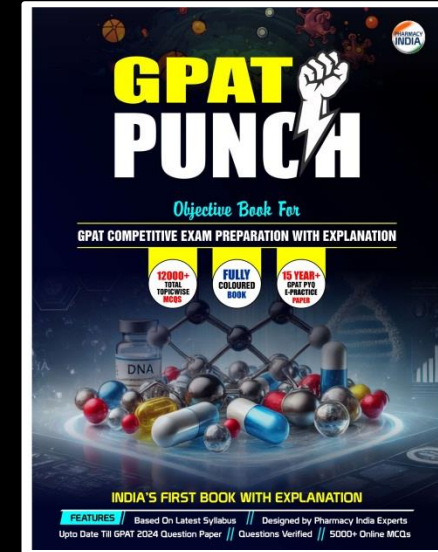
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(c) Flocculated

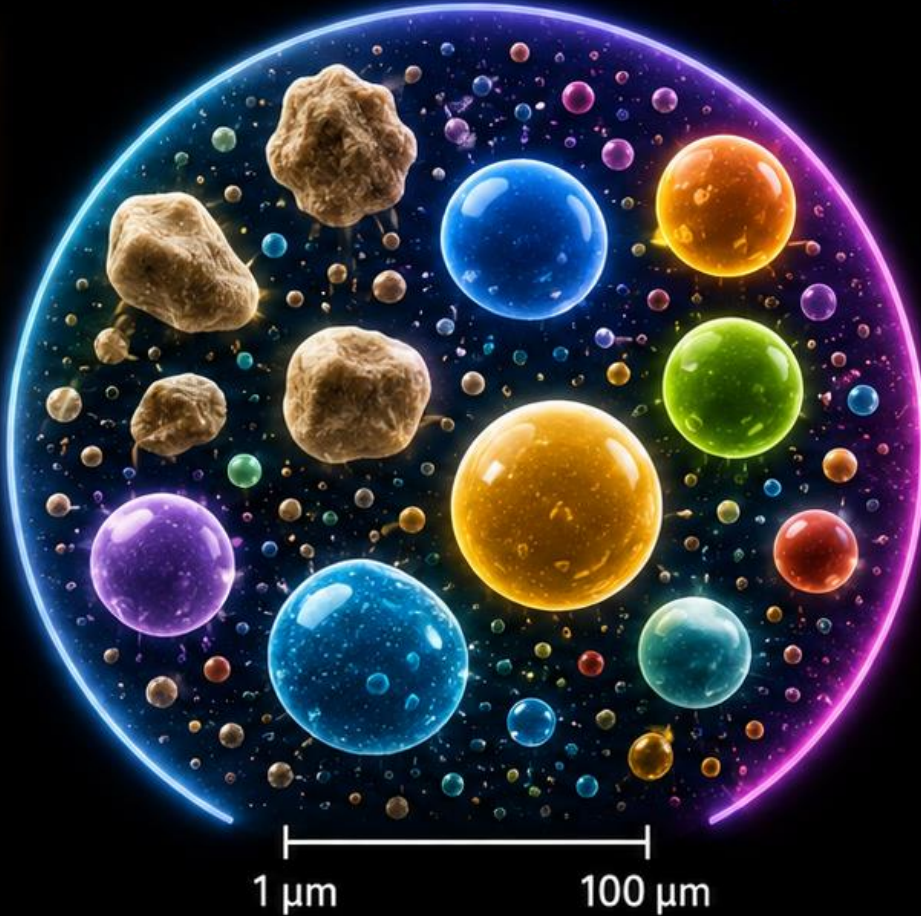
(d) Deflocculated



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COARSE DISPERSIONS

Particle size: **1-100 μm**



1



Coarse dispersions contain particles or droplets of **1-100 μm** .

2



Typical examples: **suspensions** and **emulsions**.

3



Particles are **larger** than colloidal systems.

4



They may **settle** on standing and need **shaking**.

5



Stability depends on **size control** and **viscosity**.



1-100 μm = coarse dispersion range



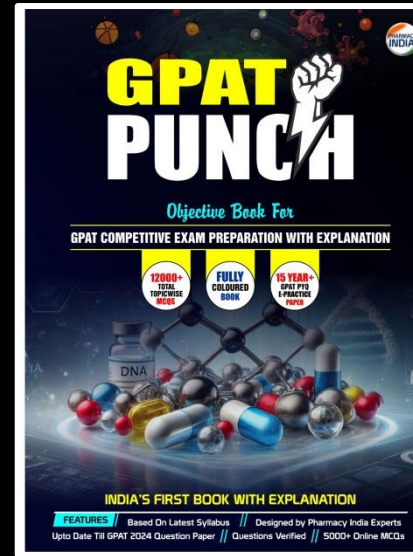


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19.

For Ideal suspension the sedimentation volume should be

- (a) Zero
- (b) Equal to one
- (c) More than one
- (d) Less than one



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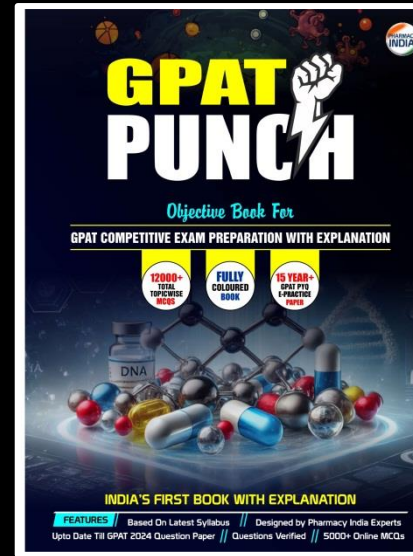


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19.

For Ideal suspension the sedimentation volume should be

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- (b) Equal to one
- (c) More than one
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IDEAL SEDIMENTATION VOLUME



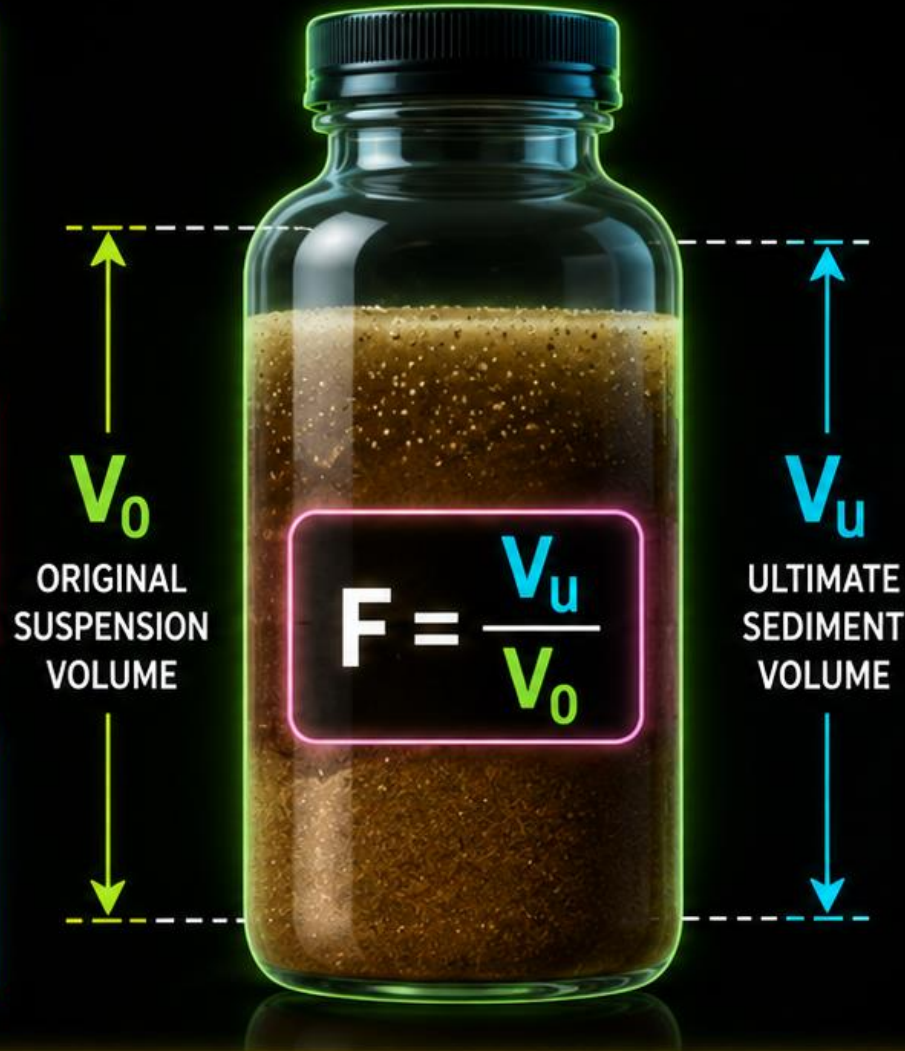
1 Sedimentation volume,
 $F = V_u / V_0$.



2 For an ideal suspension,
 $F = 1$.



3 Ultimate sediment volume equals original suspension volume.



4 Indicates no compact caking and easy redispersion.



5 A higher F value reflects better suspendability.



Ideal suspension: sedimentation volume = 1





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20.

A wetting agent is included in the formulation of a suspension particularly when the suspended particles

- (a) Are hydrophobic**
- (b) Are more denser than the vehicle**
- (c) Are water soluble**
- (d) Have lesser interfacial tension**



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20.

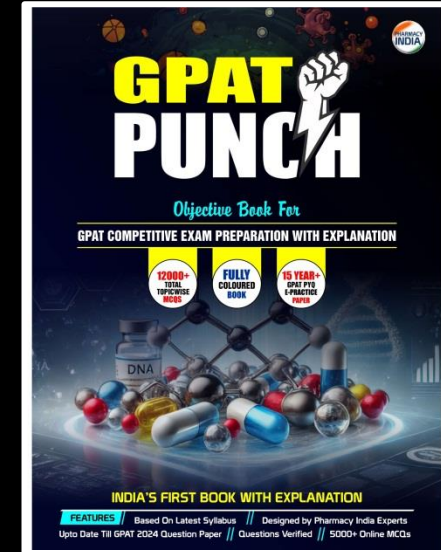
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(a) Are hydrophobic

(b) Are more denser than the vehicle

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(d) Have lesser interfacial tension



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WETTING AGENTS IN SUSPENSIONS

1



Wetting agents are needed especially for **hydrophobic particles**.

2

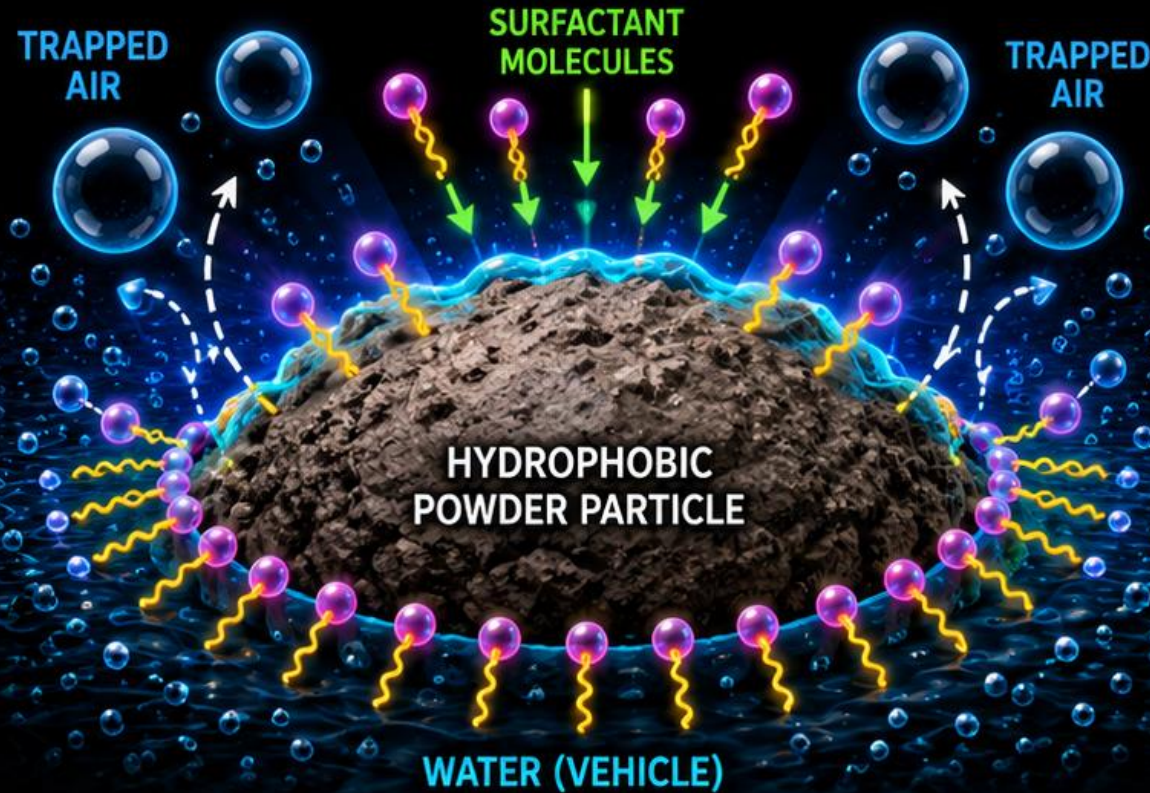


They reduce interfacial **tension** between powder and vehicle.

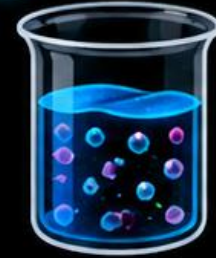
3



They **displace air** from the particle surface.



4



This helps **uniform dispersion** and prevents **floating**.

5



Examples include **surfactants** such as **polysorbates** and **SLS**.



Hydrophilic Head



Hydrophobic Tail



Air Bubble



Hydrophobic Particle



Water (Vehicle)



WETTING AGENTS IMPROVE DISPERSION OF HYDROPHOBIC POWDERS



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21.

For a flocculated suspension one of the following criterion is satisfied

- (a) High inter-particle repulsions
- (b) Strong inter-particle attractions
- (c) Weak inter-particle attractions
- (d) Weak inter-particle repulsions



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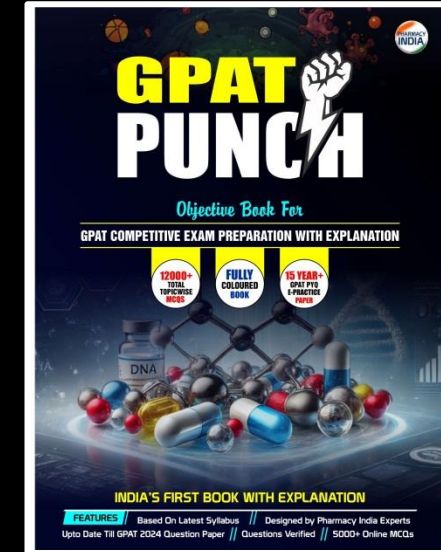
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- (a) High inter-particle repulsions
- (b) Strong inter-particle attractions
- (c) Weak inter-particle attractions
- (d) Weak inter-particle repulsions



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FLOCCULATED SUSPENSION



LOOSE, FLUFFY FLOCCULES

Floccules are loose, fluffy aggregates formed by weak attractive forces between particles.



REDUCES CAKING

Flocculation reduces compact caking and makes sediment easy to redisperse.



SETTLES FASTER

Flocculated systems settle faster than deflocculated ones, but the sediment is not hard-packed.



CLEAR SUPERNATANT

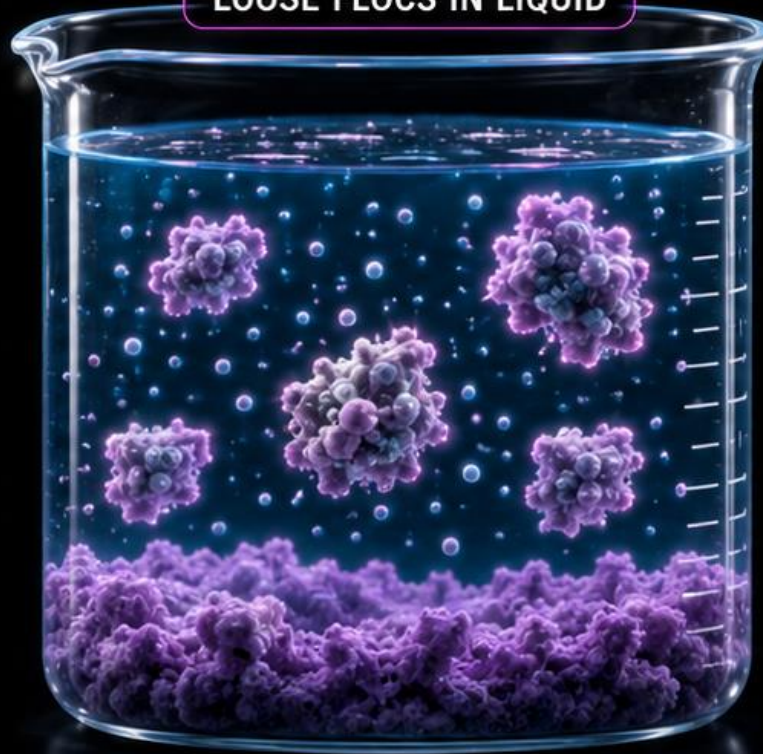
The supernatant becomes clear quickly, while the sediment remains bulky and loose.



BETTER STABILITY & UNIFORMITY

Controlled flocculation improves physical stability and ensures dose uniformity after shaking.

LOOSE FLOCS IN LIQUID



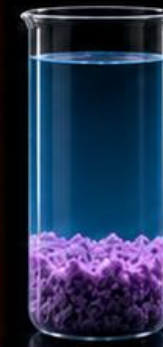
HOW FLOCS FORM



Weak van der Waals/electrostatic forces hold particles together loosely.

SETTLING BEHAVIOR

FLOCCULATED



- ✓ Faster settling
- ✓ Bulky, loose sediment
- ✓ Not hard-packed
- ✓ Clear supernatant quickly

DEFLOCCULATED



- ✗ Slower settling
- ✗ Compact, hard sediment
- ✗ Hard-packed (caking likely)
- ✗ Supernatant remains turbid longer

EASY REDISPERSION



KEY BENEFITS

- ✓ Controlled flocculation = physical stability
- ✓ Easy to redisperse = dose uniformity
- ✓ Consistent therapeutic effect
- ✓ Reduced risk of caking and grittiness



IN SHORT: Loose flocs settle fast, stay loose, redisperse easily, and deliver a uniform dose after shaking.





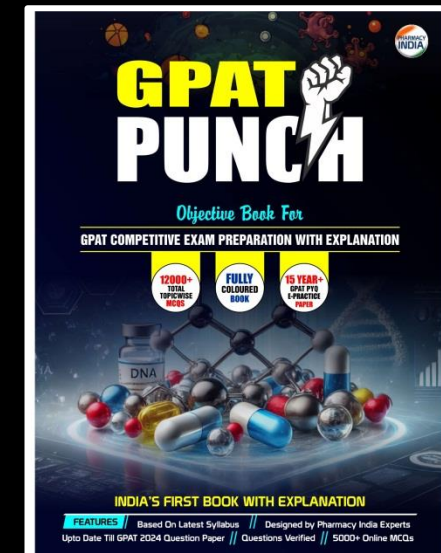
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22.

In Stoke's relationship a parameter that greatly changes the velocity of settling is

- (a) Density of the liquid
- (b) Density of particle
- (c) Radius of the particle
- (d) Viscosity of the medium



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22.

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- (a) Density of the liquid
- (b) Density of particle
- (c) Radius of the particle
- (d) Viscosity of the medium



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STOKES' LAW & SETTLING



Settling velocity is directly proportional to the square of particle radius (r^2).



Radius/particle size has the greatest effect on sedimentation rate.



Larger particles settle much faster than smaller particles.



Reducing particle size helps improve suspension stability.



Density difference and viscosity also influence settling.



↑ Particle radius (r)
→ ↑ Settling velocity



↑ ($\rho_p - \rho_m$)
→ ↑ Settling velocity



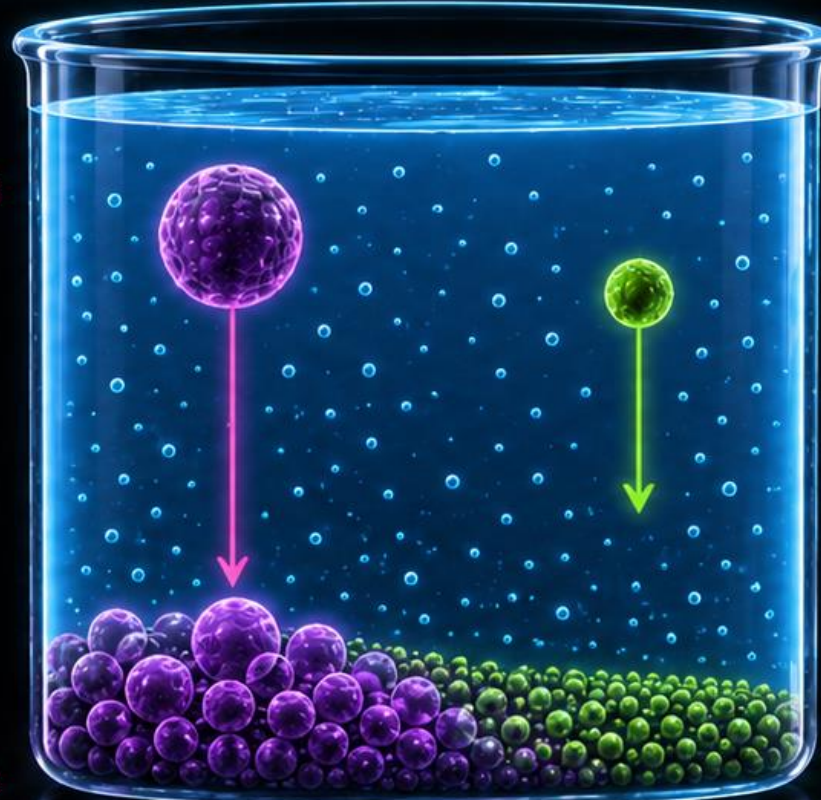
↑ Medium viscosity (η)
→ ↓ Settling velocity



↑ Gravity (g)
→ ↑ Settling velocity

FAST
SETTLING

SLOW
SETTLING



LARGER PARTICLE (r large) SETTLES FASTER
SMALLER PARTICLE (r small) SETTLES SLOWER

SLOW
SETTLING

FAST
SETTLING

STOKES' LAW (SETTLING VELOCITY)

$$v = \frac{2r^2(\rho_p - \rho_m)g}{9\eta}$$

r = particle radius (m)

ρ_p = density of particle (kg/m^3)

ρ_m = density of medium (kg/m^3)

g = acceleration due to gravity (9.81 m/s^2)

η = viscosity of medium ($\text{Pa}\cdot\text{s}$)

v = settling velocity (m/s)

FACTORS AFFECTING SETTLING VELOCITY



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23.

Methyl cellulose is a polymer of which type?

- (a) Anionic
- (b) Ampholytic
- (c) Cationic
- (d) Non-ionic



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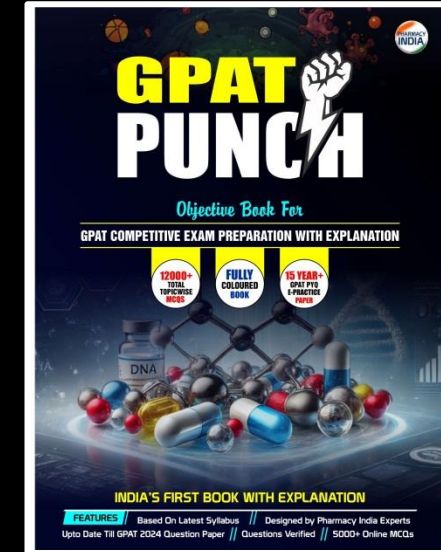
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METHYL CELLULOSE



NON-IONIC CELLULOSE DERIVATIVE

Methyl cellulose is a non-ionic, water-soluble cellulose derivative.



SUSPENDING & THICKENING AGENT

Widely used as an effective suspending and thickening agent in liquid formulations.



INCREASES VISCOSITY & SLOWS SEDIMENTATION

Increases viscosity of the medium and slows down sedimentation of particles.



IMPROVES STABILITY & REDISPERSION

Enhances physical stability and allows easy redispersion upon shaking.



COMPATIBLE & pH VERSATILE

Compatible with many formulations and effective over a wide pH range.



METHYL CELLULOSE
INCREASES VISCOSITY
& HOLDS PARTICLES
IN SUSPENSION

POLYMER CHAIN



R = $-\text{CH}_3$ (METHYL GROUP)

O = OXYGEN

— = GLUCOSE BACKBONE

HOW IT WORKS



Particles

+



Methyl
Cellulose

→



Thickened
Matrix

Methyl cellulose forms a viscous network that entraps particles and prevents settling.

KEY BENEFITS



Provides excellent physical stability



Slows sedimentation of particles



Enhances viscosity and flow control



Ensures easy redispersion



Works over a useful pH range



Non-ionic and formulation friendly



IN SHORT: Methyl cellulose **thickens**, **stabilizes**, and **keeps particles** in **uniform suspension**.





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24.

In case of suspensions all statements below are true EXCEPT that

- (a) It contains a suspending agent
- (b) It does not include a preservative
- (c) It is an injectable preparation
- (d) It is an oral preparation



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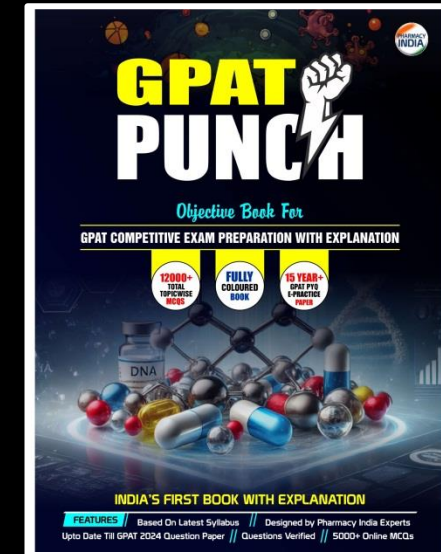


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- (d) It is an oral preparation



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PRESERVATIVES IN SUSPENSIONS



1. MOST AQUEOUS SUSPENSIONS USUALLY NEED A PRESERVATIVE.

Without preservation, microorganisms can contaminate and multiply.



2. WATER-CONTAINING FORMULATIONS ARE PRONE TO MICROBIAL GROWTH.

Bacteria, yeast, and mold can grow during storage and use.



3. SUSPENSIONS COMMONLY CONTAIN A SUSPENDING AGENT AND MAY BE ORAL OR INJECTABLE.

Regardless of route, aqueous suspensions are at risk of contamination.



4. PRESERVATIVES HELP MAINTAIN PRODUCT SAFETY AND SHELF LIFE.

They inhibit microbial growth and maintain quality over time.



5. THEREFORE, SAYING A SUSPENSION DOES NOT INCLUDE A PRESERVATIVE IS GENERALLY INCORRECT.

It contradicts standard pharmaceutical practice for most aqueous suspensions.



MICROBIAL THREATS



BACTERIA



YEAST



MOLD



OTHER MICROBES

Can cause spoilage, reduced efficacy, or even serious harm.

PRESERVATIVES WORK BY



INHIBITING MICROBIAL GROWTH



EXTENDING SHELF LIFE



MAINTAINING PRODUCT SAFETY AND QUALITY

WHERE USED



ORAL SUSPENSIONS



INJECTABLE SUSPENSIONS*

*If intended for injection, they must be sterile and appropriately preserved.



IN SHORT: Most aqueous suspensions require a **preservative** to prevent microbial growth, ensure **safety**, and maintain **quality** throughout the product's shelf life.





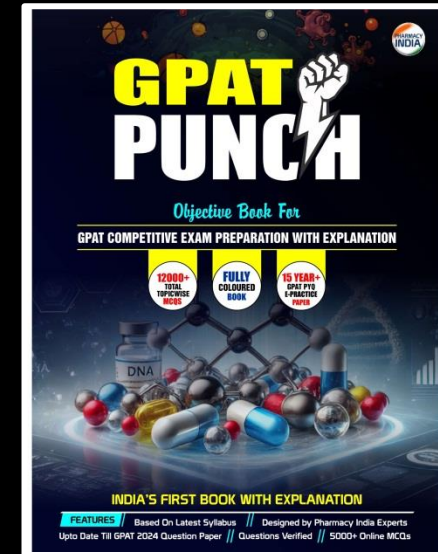
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25.

Suspended particles become flocculated in a suspension because

- (a) Attractive forces between particles are appreciable
- (b) Particles are packed closely
- (c) Repulsive forces between particles are appreciable
- (d) Vehicle rejects the particles



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25.

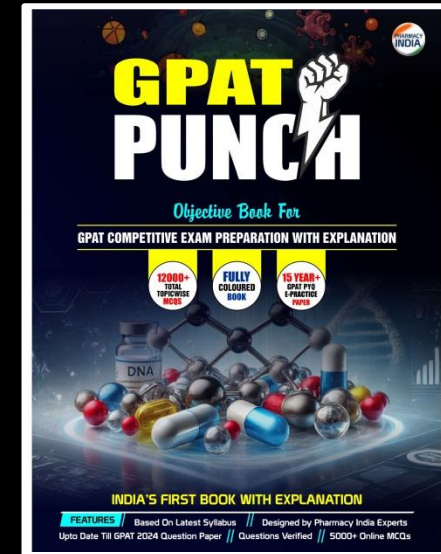
Suspended particles become flocculated in a suspension because

(a) Attractive forces between particles are appreciable

(b) Particles are packed closely

(c) Repulsive forces between particles are appreciable

(d) Vehicle rejects the particles



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CAUSE OF FLOCCULATION



1. ATTRACTIVE FORCES DOMINATE

Flocculation occurs when attractive forces between particles become appreciable.



2. REDUCED REPULSION

Reduced repulsion allows particles to aggregate into loose flocs.



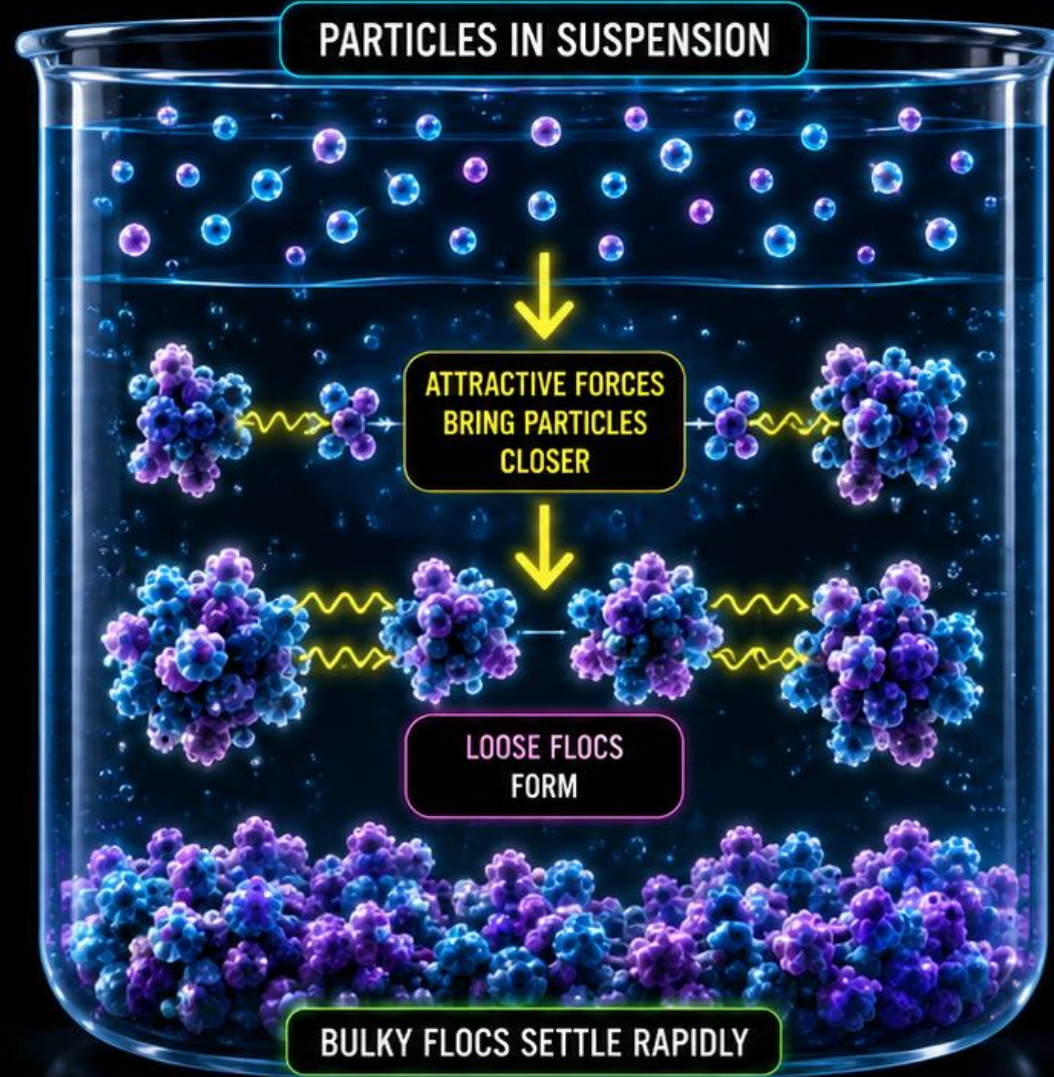
3. BULKY FLOCS

Flocs are bulky and settle rapidly.



4. LOOSE SEDIMENT

The sediment is not tightly packed, so it redisperses easily.



5. CONTROLLED FLOCCULATION

Controlled flocculation prevents hard cake formation.

EASY REDISPERSION

Loose flocs break apart easily and return to suspension.



IN SHORT: Attractive forces bring particles together, forming loose flocs that settle fast and redisperse easily.



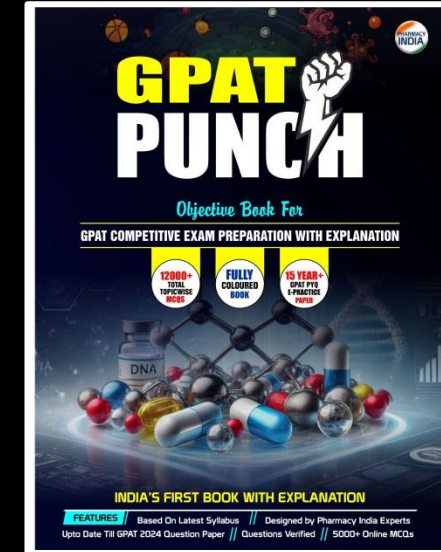


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26.

Structured vehicle is included in the formulation of a suspension in order to

- (a) Decrease the interfacial tension**
- (b) Prevent the caking of the sediment**
- (c) Prevent the sedimentation of particles**
- (d) Reduce the size by chemical means**



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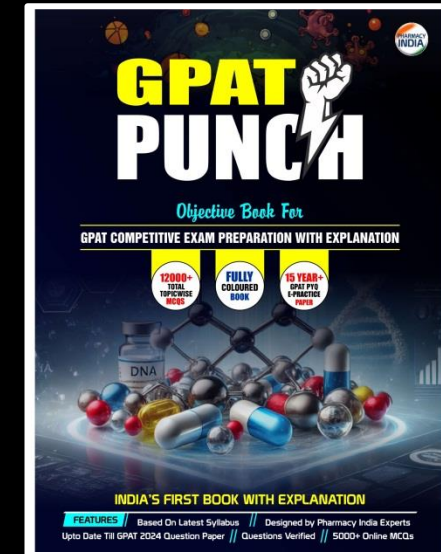
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STRUCTURED VEHICLE



VISCOUS CONTINUOUS PHASE

A structured vehicle is the viscous continuous phase of a suspension.



INCREASES VISCOSITY

It increases viscosity and slows the settling of dispersed particles.



MAINTAINS UNIFORMITY

This helps maintain uniform distribution for a longer time.



REDUCES CAKING

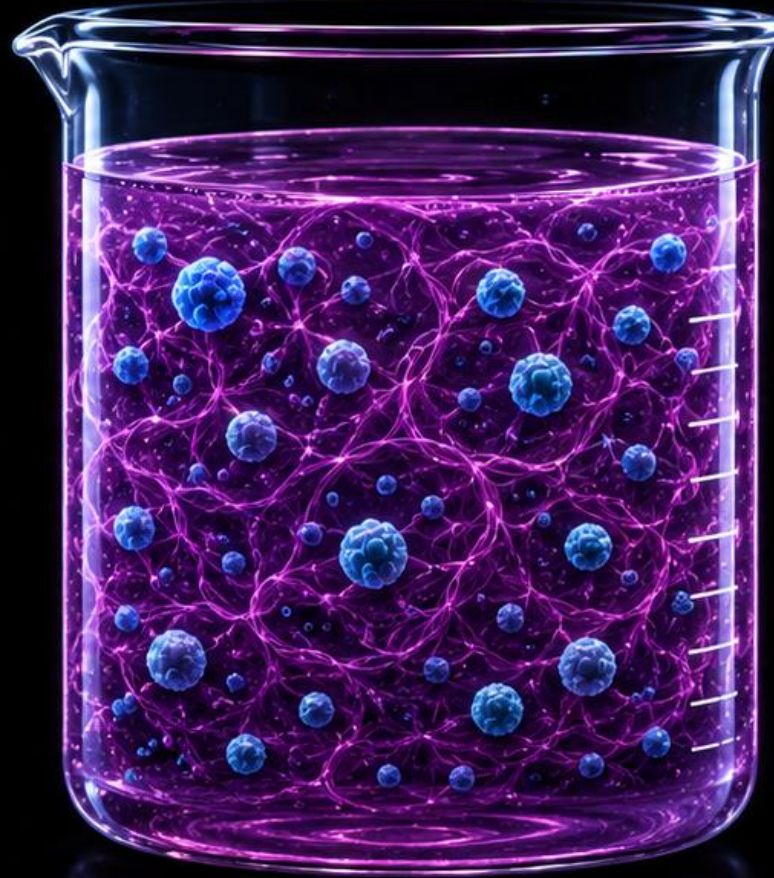
It reduces caking tendency and improves ease of redispersion.



PREPARED WITH AGENTS

Common structured vehicles are prepared with suitable suspending agents.

THICKENED SUSPENSION



HIGH VISCOSITY = SLOW SETTLING

WHY PARTICLES STAY SUSPENDED LONGER



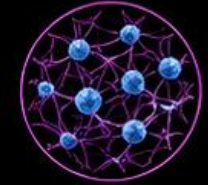
Dispersed
Particles

+



Structured
Vehicle
(High Viscosity)

→



Particles remain
suspended
longer

The viscous vehicle forms a network that resists movement and slows down particle settling.

SETTLING COMPARISON

UNSTRUCTURED VEHICLE

Low viscosity



Particles settle
faster

STRUCTURED VEHICLE

High viscosity



Particles stay suspended
for a longer time



IN SHORT: A structured vehicle *increases viscosity*, *slows settling*, *maintains uniformity*, *reduces caking*, and allows *easy redispersion*.





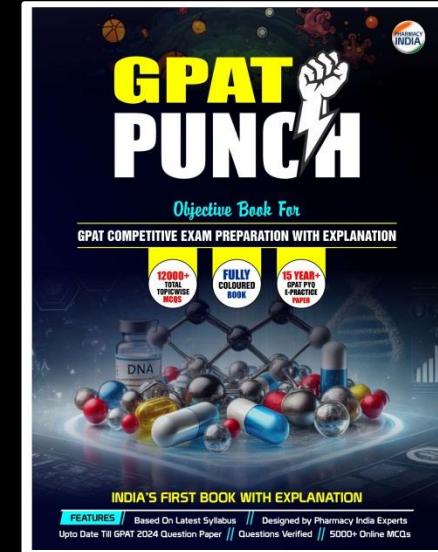
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27.

In the preparation of a structured vehicle which one of the following substances is used?

- (a) Bismuth subnitrate
- (b) Ethyl alcohol
- (c) Glycerine
- (d) Methyl cellulose



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- (d) Methyl cellulose



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METHYL CELLULOSE AS STRUCTURED VEHICLE

1



METHYL CELLULOSE is commonly used to prepare a structured vehicle.

2



IT HYDRATES IN WATER and increases viscosity.

3



AS A NON-IONIC POLYMER, it stabilizes dispersed particles.

4



IT HELPS REDUCE SEDIMENTATION and improves redispersibility.

5



IT GIVES A SMOOTH, POURABLE, PHYSICALLY STABLE SUSPENSION.



**FROM POWDER TO
STRUCTURED VEHICLE**



**VISCOUS, STRUCTURED
VEHICLE**



METHYL CELLULOSE (NON-IONIC POLYMER)



Hydrates • Thickens • Stabilizes

HOW IT WORKS



Methyl cellulose particles hydrate and form a viscous matrix.



Creates a protective network around dispersed particles.



Increases viscosity to reduce sedimentation.



Helps particles redisperse easily after storage.



Provides a smooth, pourable and physically stable suspension.



METHYL CELLULOSE = STRUCTURE • STABILITY • REDISPERSIBILITY • SMOOTH PERFORMANCE



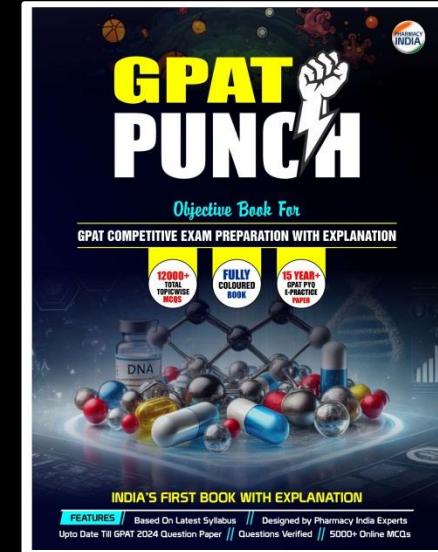
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28.

A maximum sedimentation volume will be obtained when zeta potential is

- (a) Negative
- (b) Neutral
- (c) Positive
- (d) Zero



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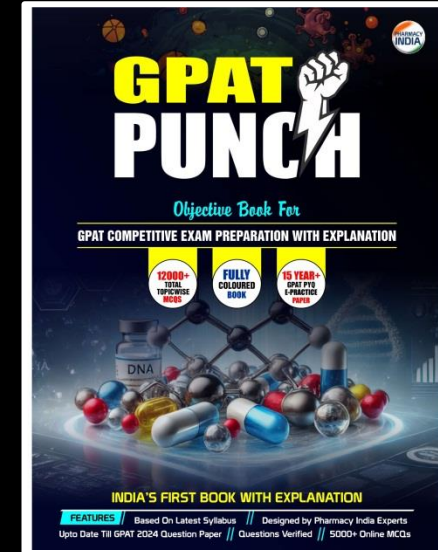


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- (d) Zero



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ZETA POTENTIAL & SEDIMENTATION VOLUME



MAXIMUM SEDIMENTATION VOLUME AT ZERO

Maximum sedimentation volume is obtained when zeta potential approaches zero.



MINIMAL REPULSION

At zero zeta potential, electrostatic repulsion is minimal.



EASY FLOCCULATION

Particles flocculate easily and form bulky, loose sediment.



BULKY FLOCS = MORE VOLUME

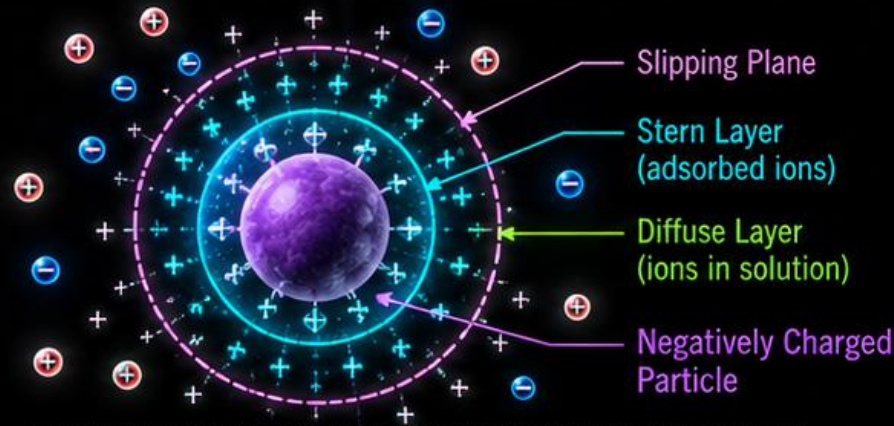
Bulky flocs occupy more volume than compact deflocculated sediment.



BETTER REDISPERSION

This improves redispersion and reduces hard caking.

ZETA POTENTIAL CONCEPT

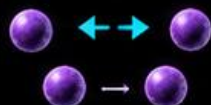


Zeta potential is the electrical potential at the slipping plane. It governs the stability of colloidal dispersions.

ZETA POTENTIAL SCALE



Strong Repulsion
Stable Dispersion



Minimal Repulsion
Bulk Flocculation



Strong Repulsion
Stable Dispersion



EFFECT ON SEDIMENTATION VOLUME

NEGATIVE ZETA (High $|-|$ mV)

Stable Dispersion



Compact Sediment
LOW VOLUME

ZERO ZETA (~0 mV)

Minimum Repulsion



Bulky Flocs
MAXIMUM VOLUME

POSITIVE ZETA (High $|+|$ mV)

Stable Dispersion



Compact Sediment
LOW VOLUME

SEDIMENTATION VOLUME



KEY TAKEAWAY: Zero zeta potential → minimal repulsion → easy flocculation → bulky flocs → maximum sedimentation volume → better redispersion → reduced hard caking.





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29.

Calcium hydrogen phosphate is dissolved in water. The apparent zeta potential initially is

- (a) Negative
- (b) Neutral
- (c) Positive
- (d) Zero



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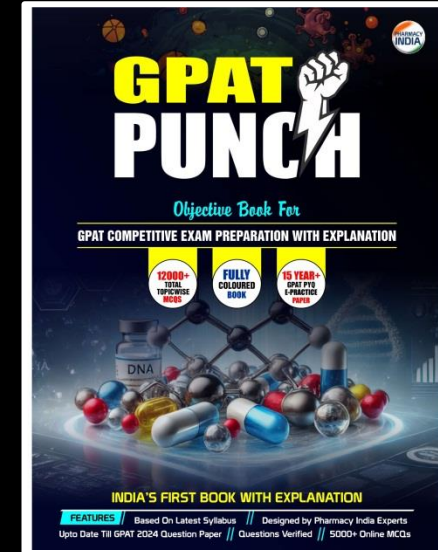


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- (c) Positive
- (d) Zero



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CALCIUM HYDROGEN PHOSPHATE

1



CALCIUM HYDROGEN PHOSPHATE IN WATER

Initially shows an apparent negative zeta potential.

2



NEGATIVE SURFACE CHARGE

The particle surface carries negative charge, producing electrostatic repulsion.

3



DEFLOCCULATION & DISPERSION

This tends to keep particles deflocculated and dispersed.

4



FLOCCULATION CAN BE INDUCED

Flocculation can be induced by adding suitable electrolytes or flocculating agents.

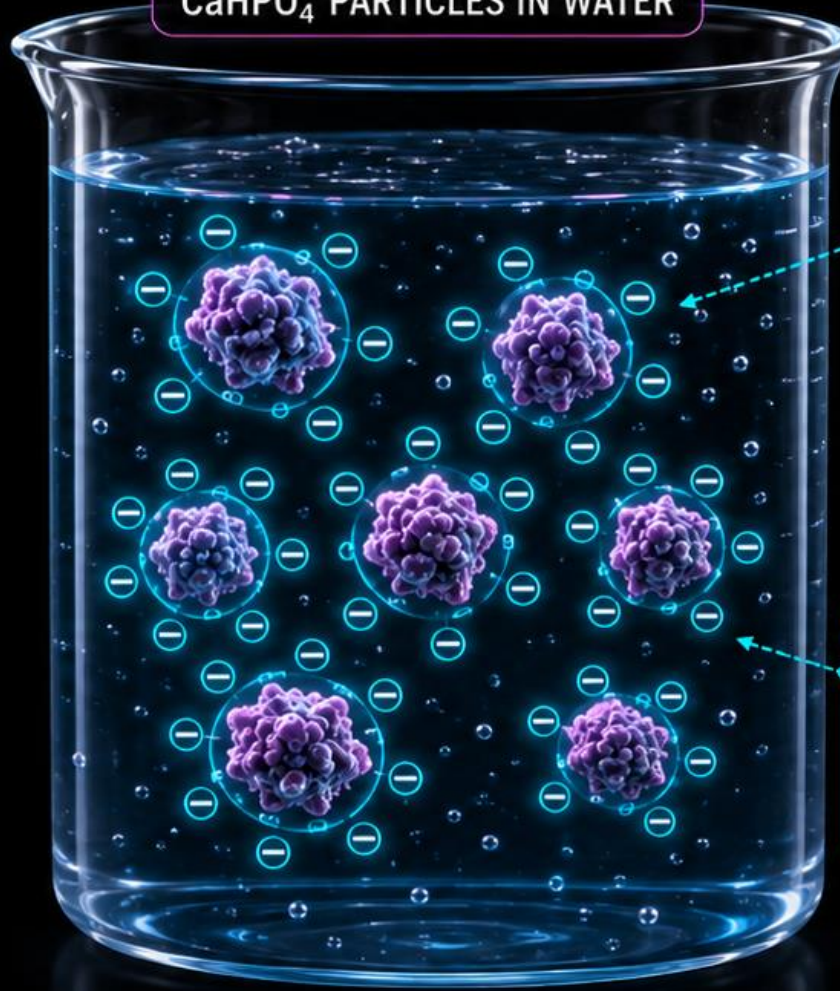
5



SURFACE CHARGE MATTERS MOST

Surface charge strongly influences suspension stability.

CaHPO₄ PARTICLES IN WATER



NEGATIVE
SURFACE
CHARGE



ZETA POTENTIAL
APPARENTLY
NEGATIVE

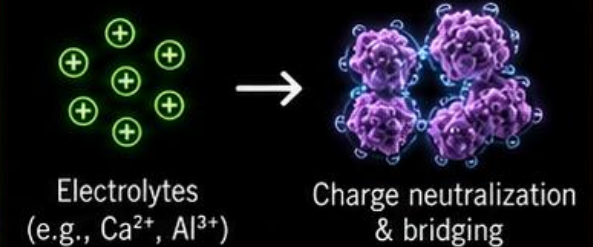


ELECTROSTATIC REPULSION



Like charges repel each other, keeping particles apart.

HOW FLOCCULATION IS INDUCED



Reduces electrostatic repulsion and promotes flocculation.



IN SHORT: CaHPO₄ particles in water carry **negative surface charge** → repel each other → remain **dispersed**. Add **electrolytes** or **flocculating agents** → reduce repulsion → **flocculation occurs**.



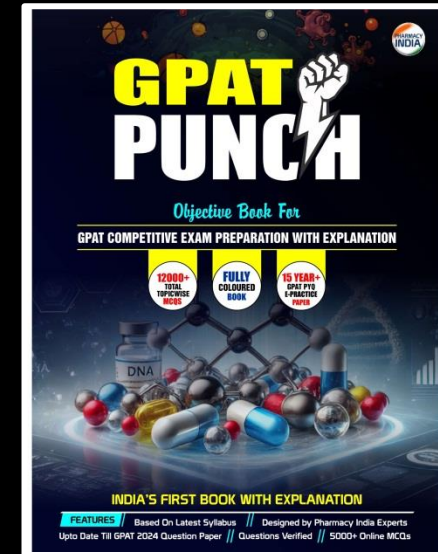


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30.

The ratio of the sedimentation volume in case of flocculated suspension to the sedimentation volume in case of deflocculated suspension is called

- (a) Sedimentation volume
- (b) Degree of flocculation
- (c) Emulsification volume
- (d) Phase volume ratio



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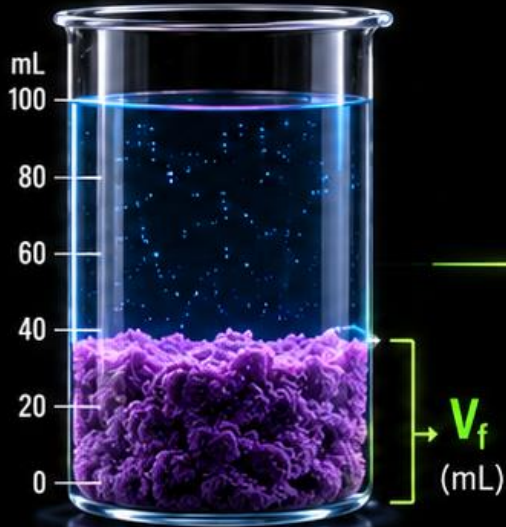


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DEGREE OF FLOCCULATION

FLOCCULATED

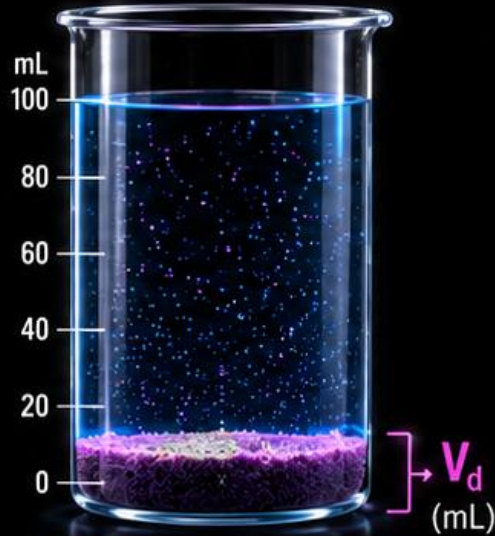
Bulkier Sediment



Large, fluffy flocs settle to a higher volume

DEFLOCCULATED

Compact Sediment



Small particles settle to a lower volume (dense sediment)

VS

β

=

Sedimentation volume of flocculated suspension (V_f)

Sedimentation volume of deflocculated suspension (V_d)

1



EXPRESSES EXTENT OF FLOCCULATION

Degree of flocculation expresses how much a system is flocculated.

2



DEFINITION

It is the ratio of sedimentation volume of flocculated to deflocculated suspension.

3



HIGHER β VALUE = MORE FLOCCULATION

A higher β value indicates more flocculation and bulkier sediment.

4



ASSESSMENT TOOL

It is used to assess physical stability and redispersibility of suspensions.

5



EASIER REDISPERSION

Flocculated systems generally show easier redispersion than deflocculated ones.



KEY TAKEAWAY:

Measure the **ratio (β)** to understand how flocculated your system is—
the **higher the value**, the **bulkier the sediment** and **better the flocculation**.





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31.

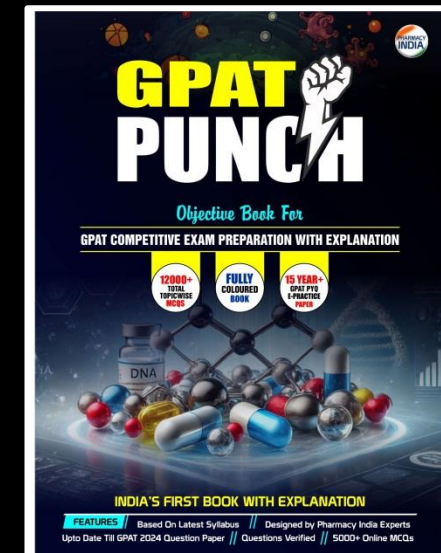
The size of dispersed particles in coarse dispersion ranges from

(a) $1\text{ }\mu\text{m}$ to $100\text{ }\mu\text{m}$

(b) 1 nm to 100 nm

(c) 1 mm to 100 cm

(d) Less than $1\text{ }\mu\text{m}$



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31.

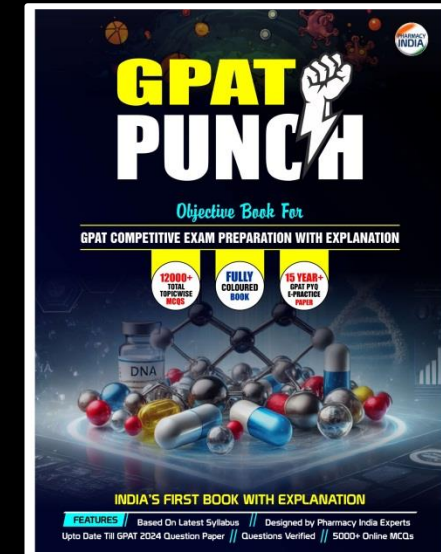
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(c) $1\ \text{mm}$ to $100\ \text{cm}$

(d) Less than $1\ \mu\text{m}$



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COARSE DISPERSION PARTICLE SIZE



Coarse dispersions have particle size about **$1\ \mu\text{m}$ to $100\ \mu\text{m}$** .



They contain relatively **large dispersed particles**.



DISPERSING MEDIUM (LIQUID)

DISPERSED PARTICLES ($1\ \mu\text{m} - 100\ \mu\text{m}$)



Common examples: **suspensions** and **emulsions**.

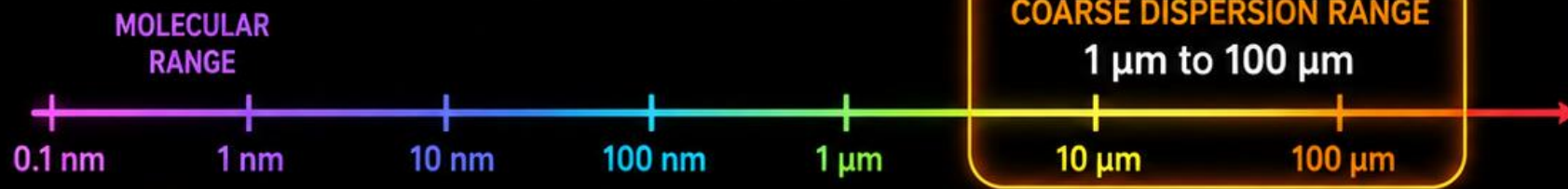


Large particle size can cause **faster settling** or **creaming**.



Proper **stabilization** improves **uniformity** and **redispersibility**.

PARTICLE SIZE SCALE



VISIBLE PARTICLES



KEY TAKEAWAY: Coarse dispersions ($1\ \mu\text{m} - 100\ \mu\text{m}$) contain large particles that are visible under a microscope, prone to **settling or creaming**, and require **stabilization** for long-term **uniformity**.



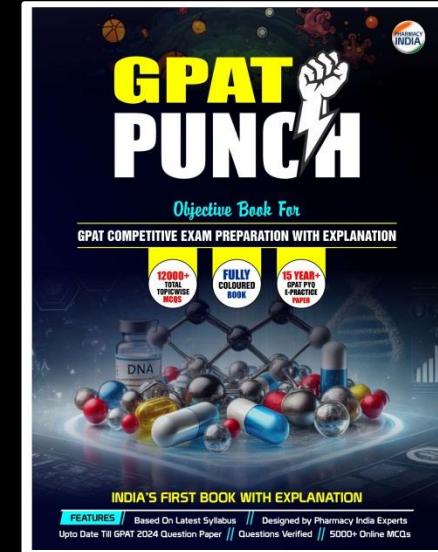
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32.

In flocculated suspension the rate of sedimentation is

- (a) Low
- (b) More
- (c) Zero
- (d) 50%



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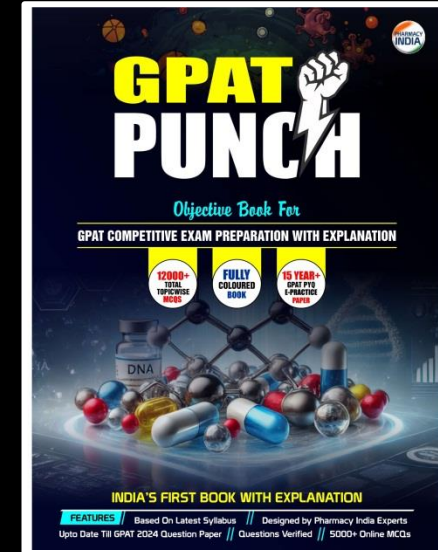
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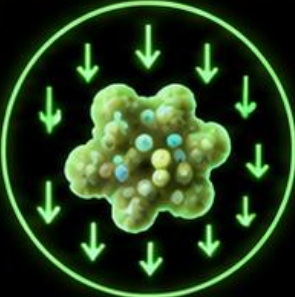
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FLOCCULATED SUSPENSION



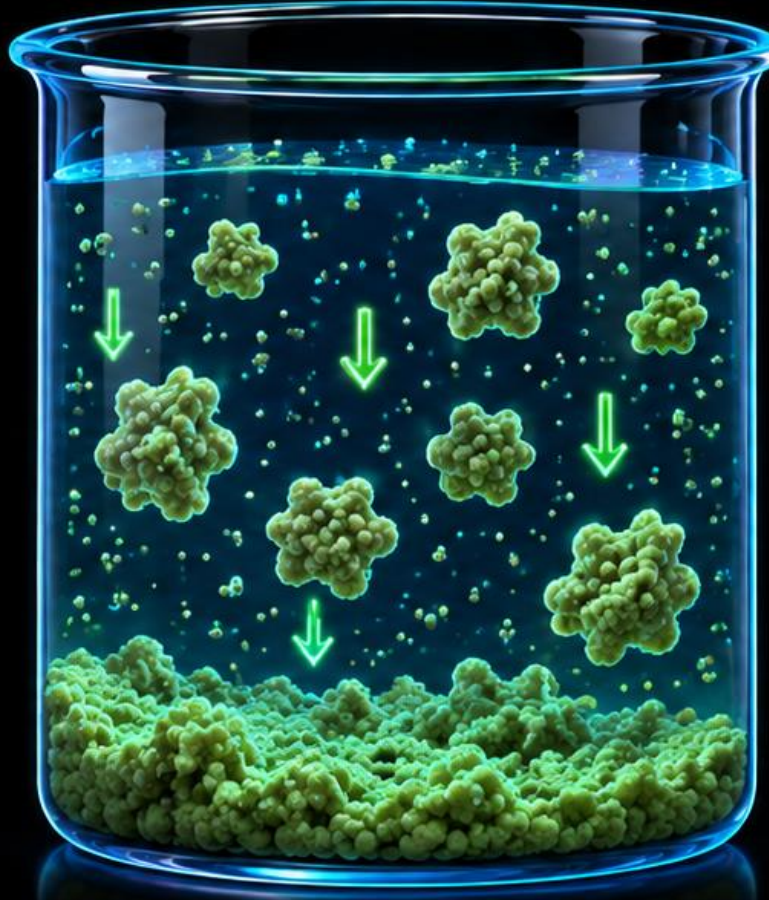
1. PARTICLES AGGREGATE INTO LOOSE FLOCS.

Individual particles come together to form large, loose flocs.



2. FLOCS ARE LARGER AND SETTLE FASTER.

Due to increased size and mass, flocs settle more quickly.



3. SEDIMENTATION RATE IS MORE IN FLOCCULATED SYSTEMS.

Flocculation significantly enhances the settling rate of particles.



4. THE SEDIMENT IS POROUS AND EASY TO REDISPERSE.

The loose, open structure allows easy redispersion with gentle agitation.



5. FLOCCULATION REDUCES HARD CAKE FORMATION.

Porous flocculated sediment does not compact into a hard cake, making filtration, handling, and resuspension easier.



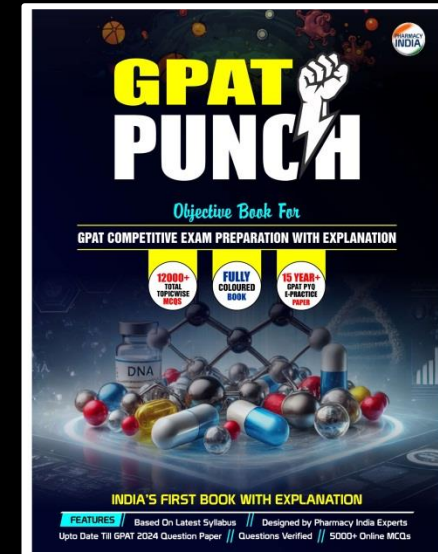
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33.

If zeta potential of a suspension is high then the system will be considered as

- (a) Deflocculation
- (b) Flocculation
- (c) Emulsion
- (d) Sedimentation



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33.

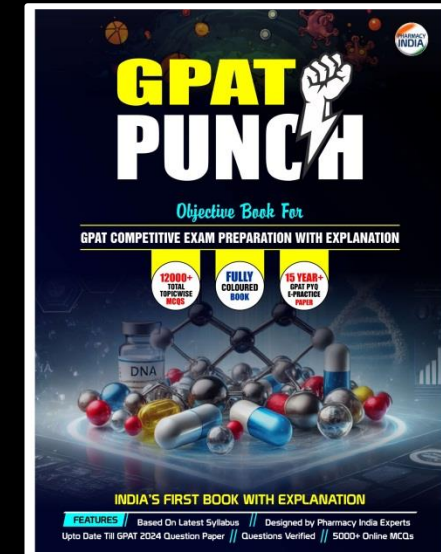
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(a) Deflocculation

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(c) Emulsion

(d) Sedimentation



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HIGH ZETA POTENTIAL = DEFLOCCULATION



1. HIGH ZETA POTENTIAL

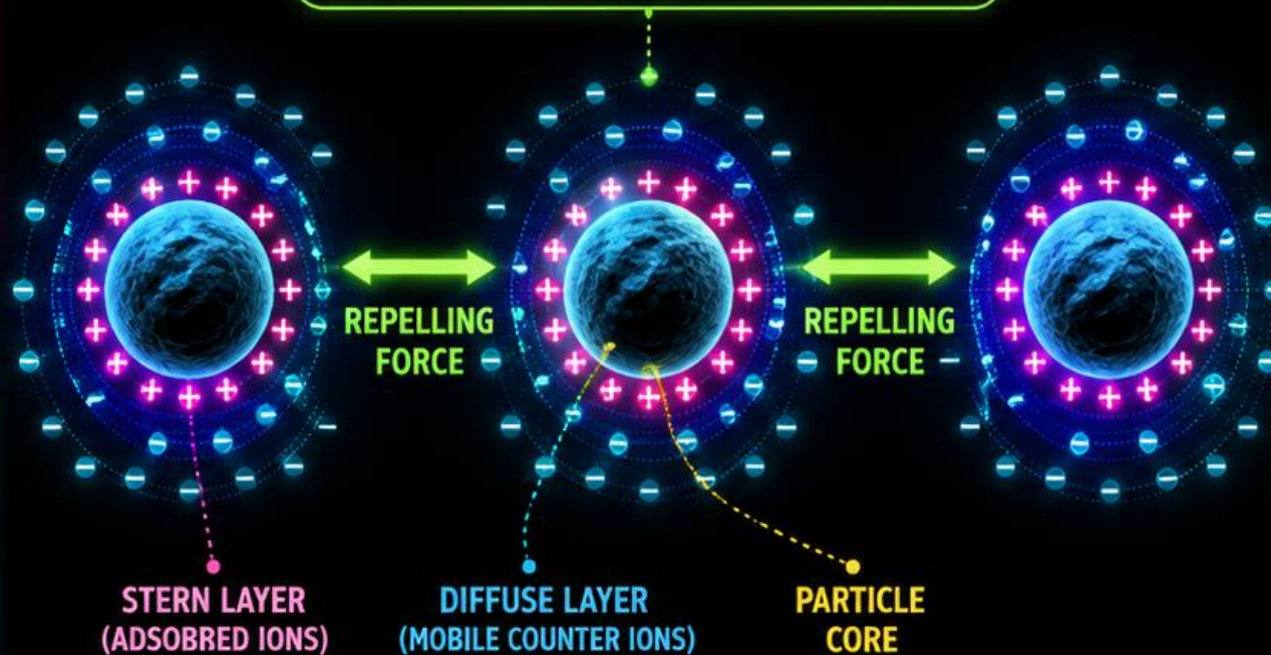
High zeta potential means strong electrostatic repulsion.



2. PARTICLES STAY SEPARATE

Particles stay separate instead of forming flocs.

STRONG ELECTROSTATIC
REPULSION KEEPS PARTICLES APART



HIGH ZETA POTENTIAL
= THICK DOUBLE LAYER
= STRONG REPULSION



3. DEFLOCCULATED SYSTEM

Such a system is considered deflocculated.



4. INDIVIDUAL SETTLING

Particles settle individually.



5. COMPACT SEDIMENT & CAKING

Deflocculated systems may form compact sediment and caking.



HIGH YIELD TAKEAWAY

Higher zeta potential → stronger repulsion → no floc formation → particles settle separately → compact sediment & caking may occur.

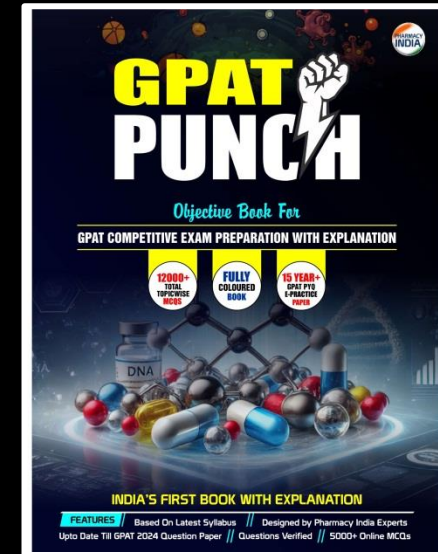


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34.

The value of sedimentation volume (F) gives a knowledge about the _____ of the suspension

- (a) Physical stability
- (b) Incompatibility
- (c) Solubility
- (d) All of the above



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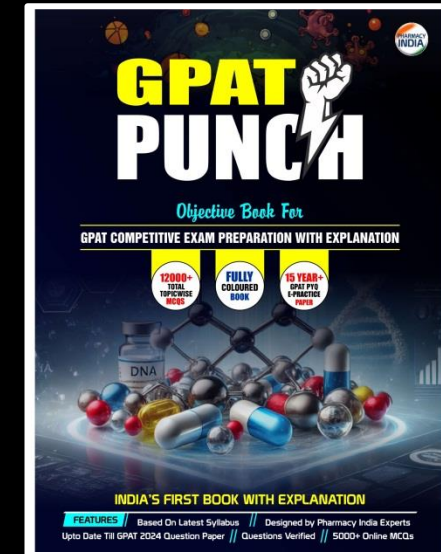
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The value of sedimentation volume (F) gives a knowledge about the _____ of the suspension

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SEDIMENTATION VOLUME (F)



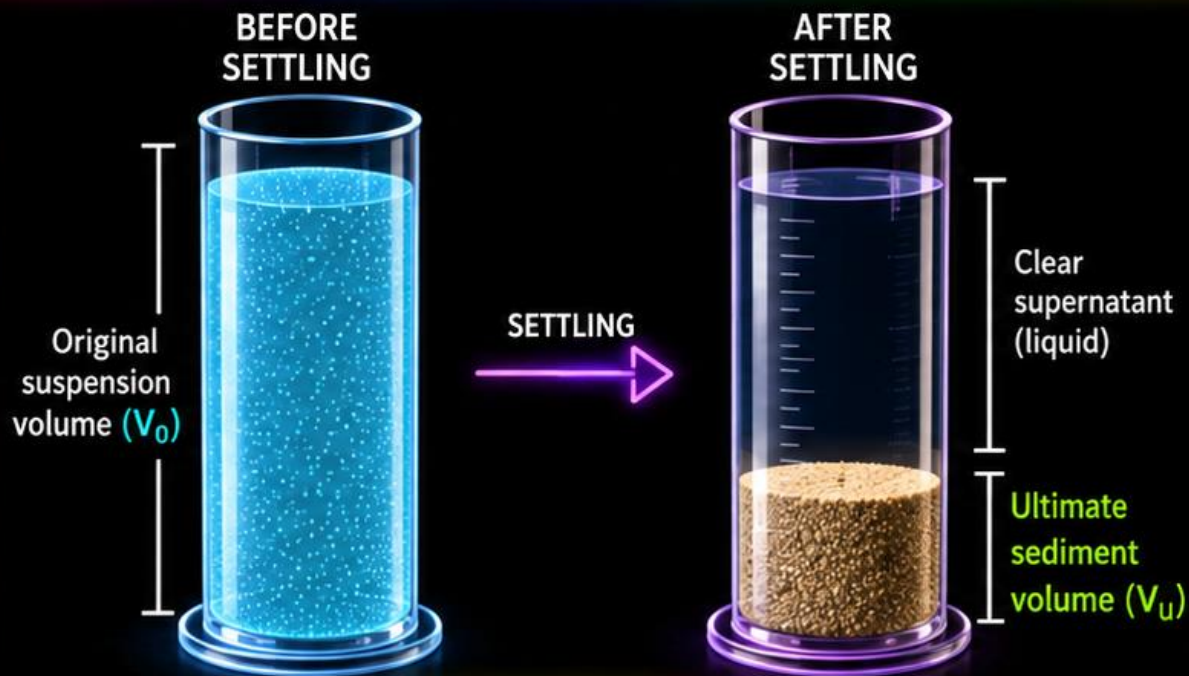
Sedimentation volume gives information about **physical stability**.



F = ultimate sediment volume / original suspension volume.



It indicates how much sediment **remains after settling**.



A higher **F** usually suggests better **suspendability**.



It is useful for comparing suspension **formulations**.



KEY TAKEAWAY

F is a simple, practical index to evaluate and compare the physical stability and suspendability of suspensions.

$$F = \frac{V_u}{V_0}$$

where, V_u = ultimate sediment volume
 V_0 = original suspension volume



Physical Stability



Suspension Science



Evaluate



Compare



Better
Therapeutic
Performance



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35.

The suspensions having particle size _____ are categorized as coarse suspension

- (a) Greater than 1 μm
- (b) Greater than 10 μm
- (c) Both of the above
- (d) None of the above



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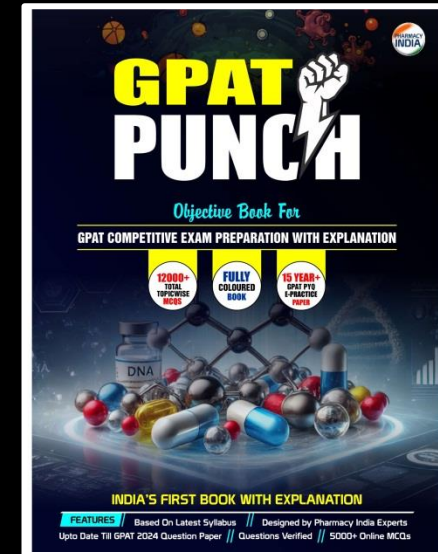
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- (b) Greater than $10\ \mu\text{m}$
- (c) Both of the above
- (d) None of the above



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COARSE SUSPENSION

PARTICLES ARE LARGE ENOUGH TO SEE, HEAVY ENOUGH TO SETTLE



1. COARSE PARTICLES

Coarse suspensions contain particles **greater than 1 μm** .



2. VISIBLE UNDER MICROSCOPE

These particles are **visible** under a microscope.



4. WETTING & SUSPENDING AGENTS

Wetting agents **reduce surface tension** and improve particle wetting.
Suspending agents **increase viscosity** and prevent rapid settling.



3. SETTLE UNDER GRAVITY

Because of their size, they **settle under gravity** if left undisturbed.



5. BETTER FORMULATION BENEFITS

Good formulation improves **appearance** and ensures uniform **dose distribution**.



VISIBLE PARTICLES

Easily observed under microscope



SETTLE OVER TIME

Require shaking before use



STABILITY MATTERS

Proper agents ensure uniform suspension



UNIFORM DOSING

Prevents dose variation



BETTER APPEARANCE

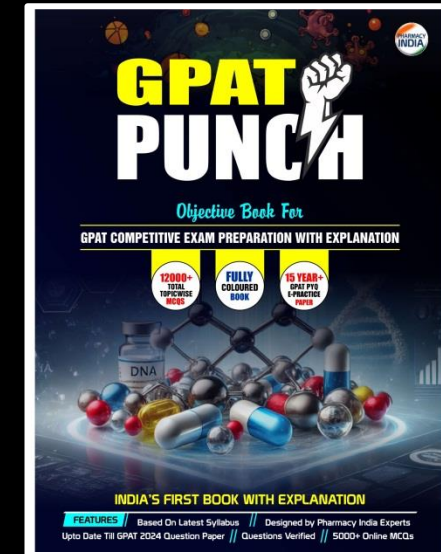
Smooth texture & patient acceptability



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36. The flocculated suspension is one in which zeta potential of particle is

- (a) -05 to $+05$ mV
- (b) -10 to $+10$ mV
- (c) -20 to $+20$ mV
- (d) -30 to $+30$ mV



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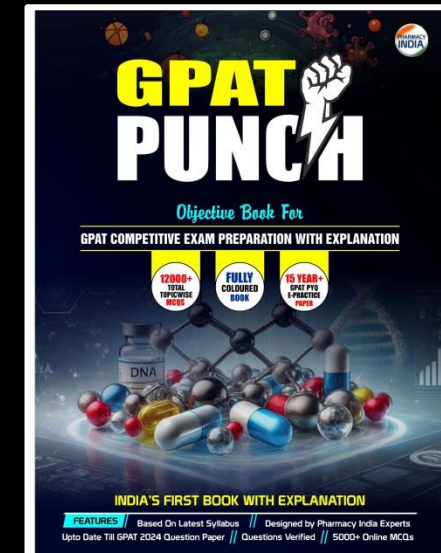
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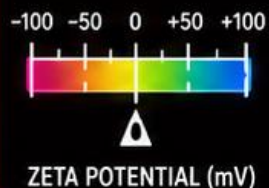
ZETA POTENTIAL IN FLOCCULATION

1

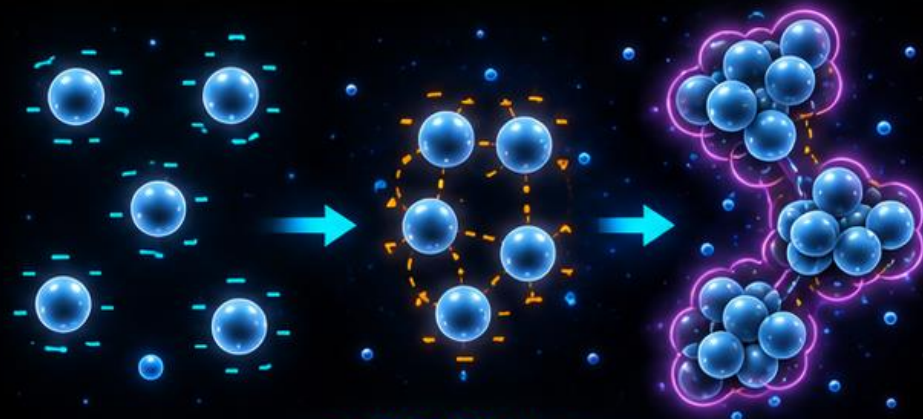


Flocculated suspensions have relatively low zeta potential.

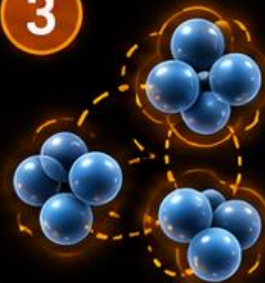
2



A typical flocculated range is around **-20 mV to +20 mV.**

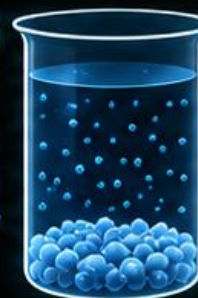


3



Low repulsion allows particles to come together as **loose flocs.**

4



Sedimentation becomes rapid but the sediment is **fluffy.**



5



SHAKE



The sediment is **easily redispersed** on shaking.





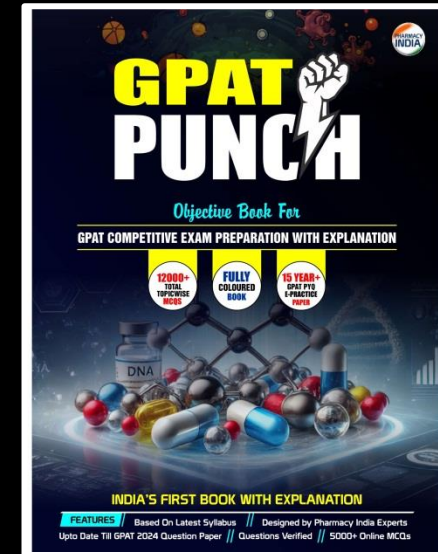
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37.

Suspension involves individual particle settling

- (a) Flocculated
- (b) Deflocculated
- (c) Both of the above
- (d) None of the above



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37.

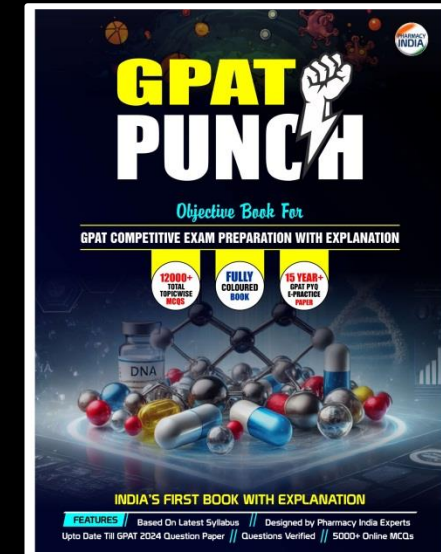
Suspension involves individual particle settling

(a) Flocculated

(b) Deflocculated

(c) Both of the above

(d) None of the above



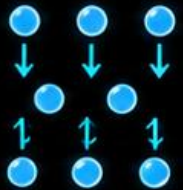
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DEFLOCCULATED SUSPENSION

Particles Settle Individually



Particles remain **separate** and do not form flocs.



Individual **particle settling** occurs in deflocculated suspension.

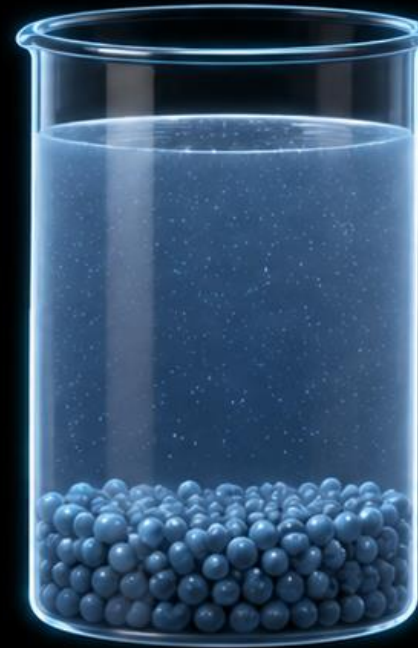


Sedimentation is **slower** at first.

INITIAL SUSPENSION



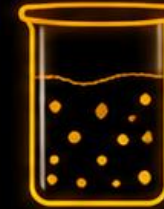
AFTER TIME



TIME



In a **deflocculated suspension**, particles are discrete and **independent**. Each particle settles on its own based on **size and density**.



The supernatant **stays cloudy** for longer.



Sediment becomes **compact** and may be difficult to **redisperse**.

★ DISCRETE PARTICLES | INDIVIDUAL SETTLING | SLOWER CLARIFICATION | CLOUDY SUPERNATANT | COMPACT SEDIMENT ★



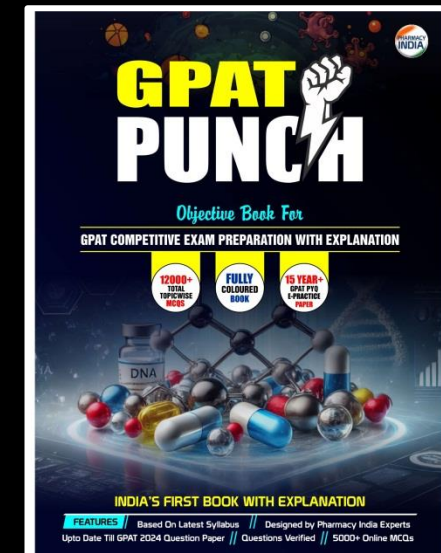
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38.

To identify the emulsion type which of the following tests are conducted

- (a) Dilution test
- (b) Dye test
- (c) Conductivity test
- (d) All of the above



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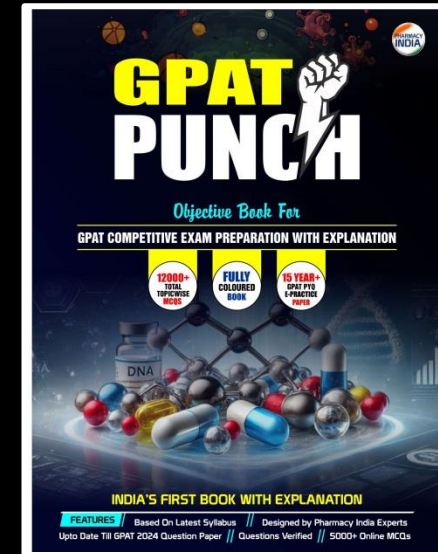


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To identify the emulsion type which of the following tests are conducted

- (a) Dilution test
- (b) Dye test
- (c) Conductivity test
- (d) All of the above



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EMULSION TYPE IDENTIFICATION



Emulsion type can be identified by multiple tests.

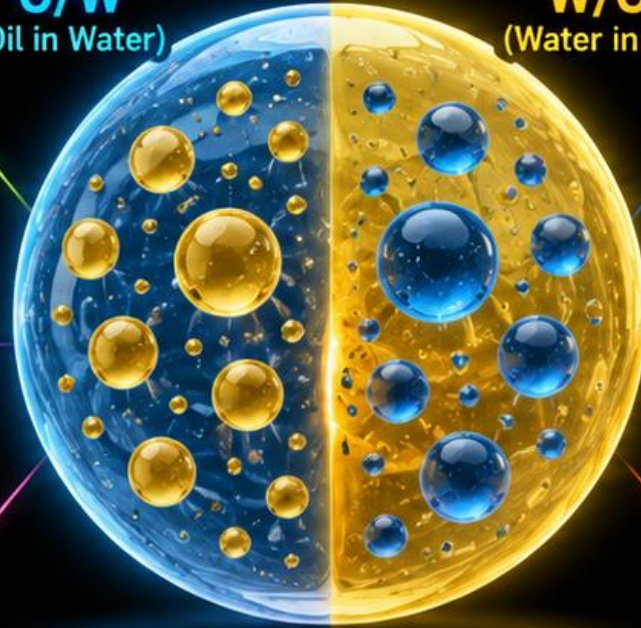


Dilution test checks compatibility with the external phase.



Dye test shows which phase is continuous.

O/W
(Oil in Water)



W/O
(Water in Oil)



Conductivity test identifies whether water is the external phase.



O/W emulsions dilute with **water** and **conduct electricity**.



W/O emulsions dilute with **oil** and show **poor conductivity**.

THREE SIMPLE TESTS

① DILUTION TEST

Add a small amount of emulsion to the test liquid and shake.

Dilutes / Stable



Same as external phase



Does not Dilute



Different from external phase

② DYE TEST

Add a water-soluble dye and observe where the color appears.

Dye spreads throughout = Continuous phase



O/W
(Dye in water phase)

Dye remains in droplets = Dispersed phase



W/O
(Dye in water droplets)

③ CONDUCTIVITY TEST

Measure electrical conductivity of the emulsion.

High Conductivity
(Good conductor)



O/W Emulsion
(water is external phase)

Low Conductivity
(Poor conductor)



W/O Emulsion
(oil is external phase)



QUICK RECAP:

Dilution → tells compatibility

Dye → tells continuous phase

Conductivity → confirms external phase





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39.

Which of the following is not used as an emulsifying agent?

- (a) Surfactant
- (b) Hydrophilic colloid
- (c) Electrolytes
- (d) Finely divided solids



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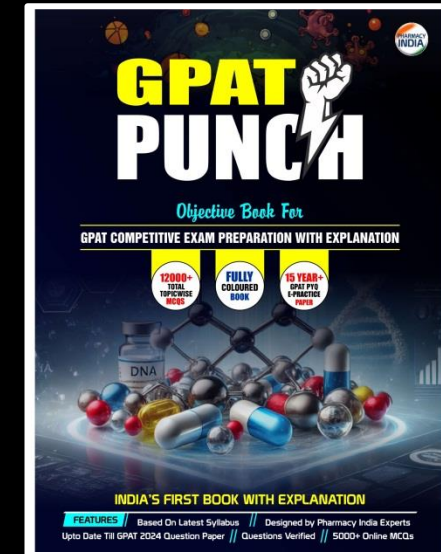
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- (a) Surfactant
- (b) Hydrophilic colloid
- (c) Electrolytes
- (d) Finely divided solids



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EMULSIFYING AGENTS



1. COMMON EMULSIFYING AGENTS INCLUDE SURFACTANTS.

Surfactants have both **hydrophilic** (water-loving) and **hydrophobic** (oil-loving) parts that concentrate at the oil-water interface.



3. FINELY DIVIDED SOLIDS STABILIZE SOME EMULSIONS.

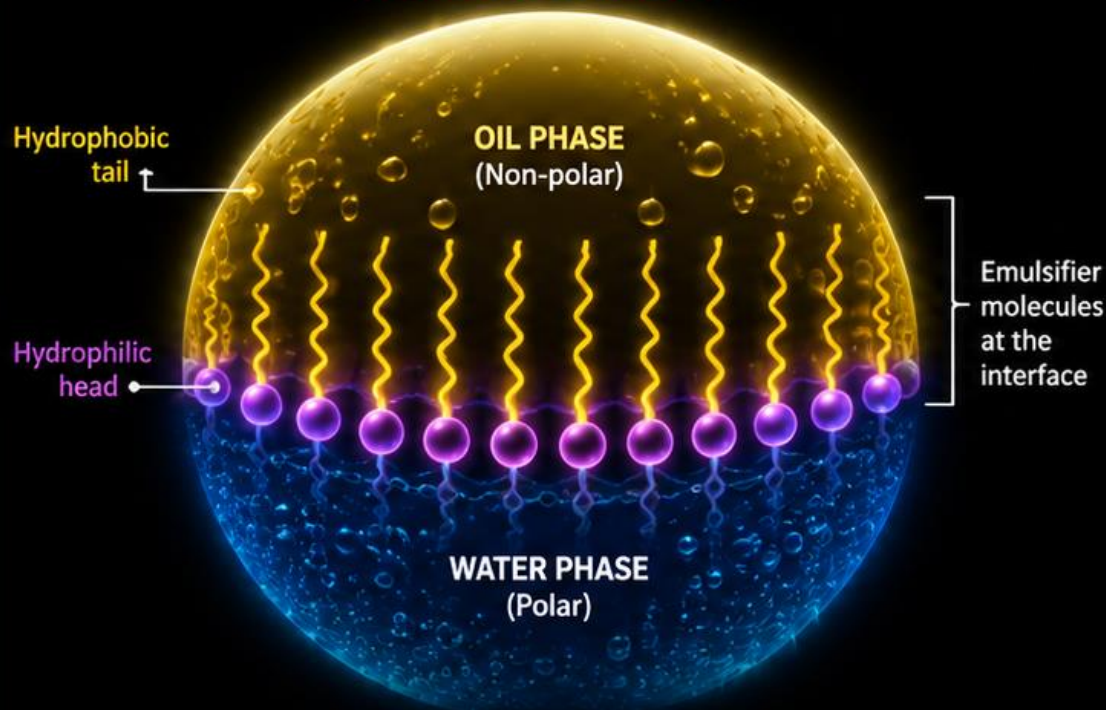
In solid-stabilized (Pickering) emulsions, hydrophobic particles adsorb at the interface and create a **mechanical barrier** that prevents droplet coalescence.



5. EMULSIFIERS REDUCE INTERFACIAL TENSION OR FORM A PROTECTIVE FILM.

They **lower the energy** required to create new interface and/or form a viscoelastic film that **protects droplets** from coalescing.

EMULSION INTERFACE



2. HYDROPHILIC COLLOIDS CAN ALSO ACT AS EMULSIFIERS.

Natural colloids like **gums**, **proteins**, **starches**, and **cellulose derivatives** form hydrated layers around droplets and stabilize emulsions.



4. ELECTROLYTES ARE NOT USED AS PRIMARY EMULSIFYING AGENTS.

Electrolytes can **reduce the stability** of emulsions by decreasing the charge and **compression of the interfacial layer**, leading to **flocculation** or coalescence.

CLASSIFICATION OF EMULSIFIERS



SURFACTANTS

e.g., Soaps, Detergents, SLS, Polysorbates



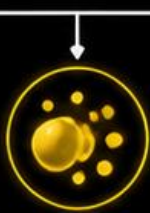
NATURAL COLLOIDS

e.g., Gum acacia, Gelatin, Starch, Pectin, CMC



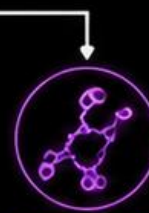
PROTEINS

e.g., Casein, Whey protein, Egg albumin, Soy protein



SOLID PARTICLES

e.g., Silica, Clay, CaCO₃, Talc



POLYMERS

e.g., PVA, PEG, Xanthan, Alginate



KEY TAKEAWAY

Emulsifying agents stabilize emulsions by acting at the interface—lowering interfacial tension and/or forming a protective barrier around droplets.

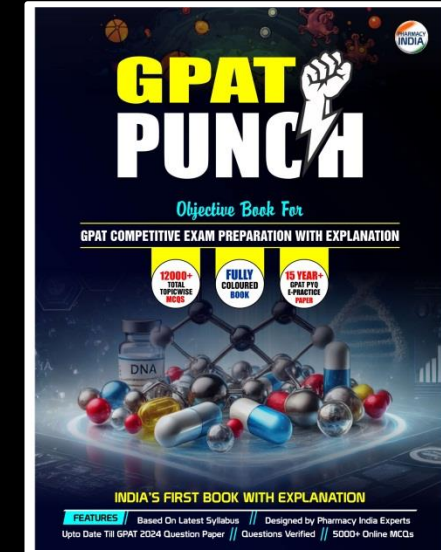


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40. Ideal phase volume ratio per stable emulsion

- (a) 25:75
- (b) 50:50
- (c) 75:25
- (d) 33:67



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40.

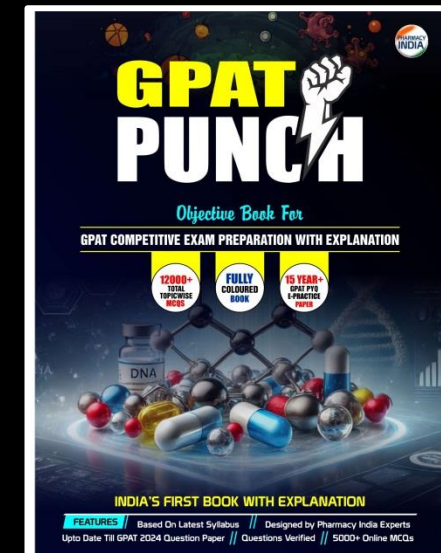
Ideal phase volume ratio per stable emulsion

(a) 25:75

(b) 50:50

(c) 75:25

(d) 33:67



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STABLE EMULSION PHASE RATIO



A **75:25** phase volume ratio is a commonly cited ideal ratio for a **stable emulsion** in this context.



Proper phase ratio helps maintain **emulsion stability**.



75%
CONTINUOUS
PHASE

25%
DISPERSED
PHASE



Too much **dispersed phase** increases **coalescence risk**.



Emulsifier choice and **HLB** still affect stability.



Viscosity and **mixing** also influence the final **emulsion**.

PHASE RATIO
75 : 25
CONTINUOUS : DISPERSED



CONTINUOUS PHASE

External phase in which the dispersed droplets are suspended.



DISPERSED PHASE

Internal droplets dispersed within the continuous phase.



STABLE EMULSION

Small uniform droplets, proper ratio, and suitable formulation = stability.



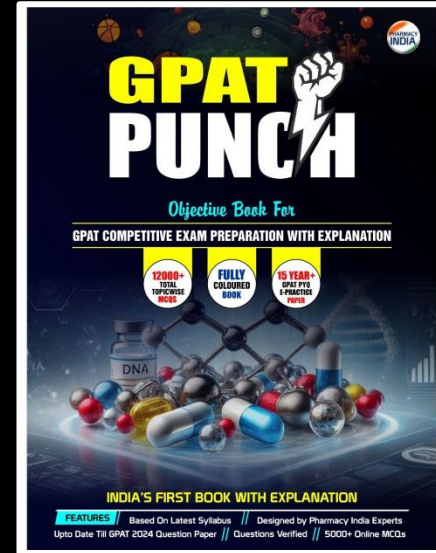
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41.

Thermodynamically emulsion is

- (a) Stable
- (b) Unstable
- (c) Both
- (d) None of the above



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41.

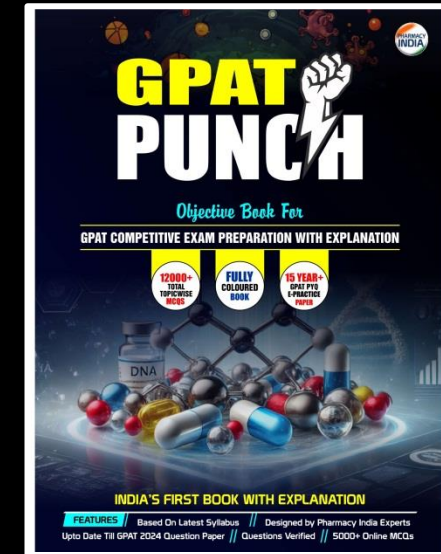
Thermodynamically emulsion is

(a) Stable

(b) Unstable

(c) Both

(d) None of the above



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THERMODYNAMIC INSTABILITY OF EMULSIONS

Emulsions are useful but **not** at thermodynamic equilibrium.



1. TWO IMMISCIBLE LIQUIDS

Emulsions contain oil (**dispersed phase**) and water (**continuous phase**) that do not mix.



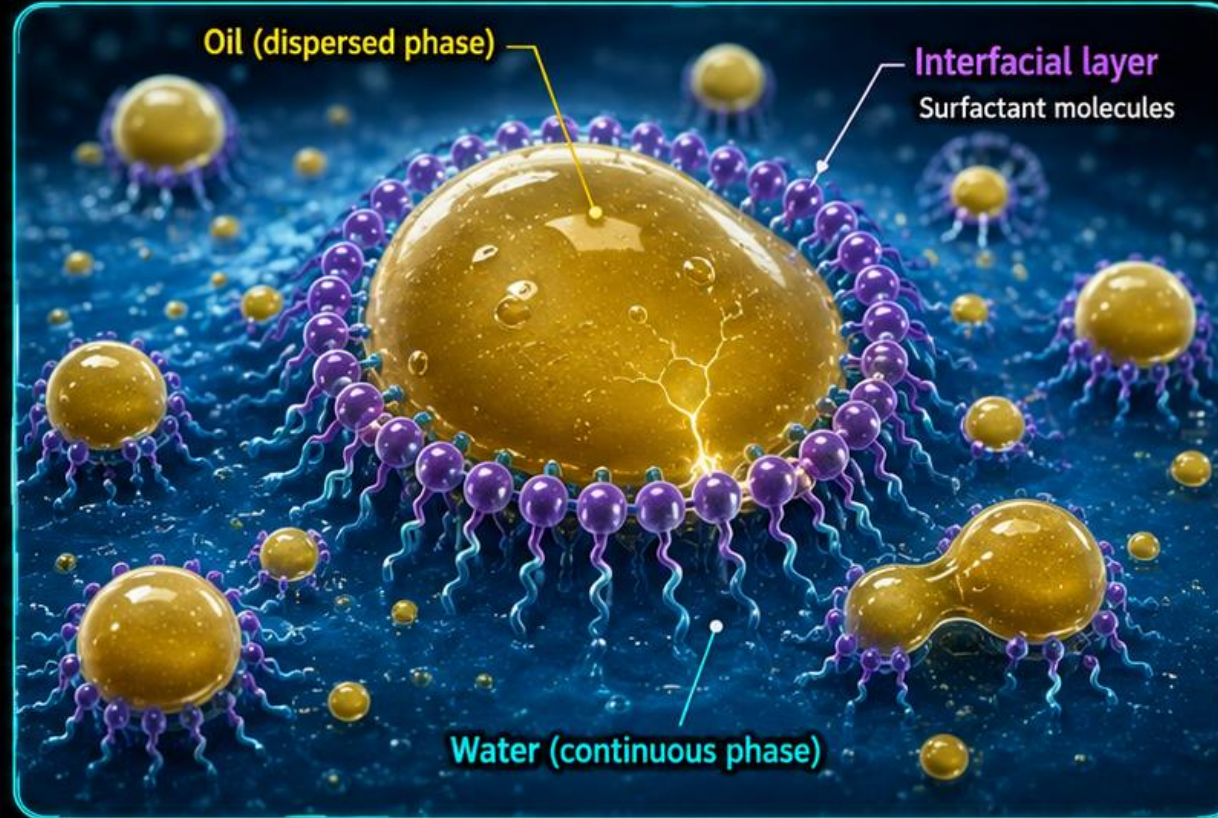
2. HIGH INTERFACIAL FREE ENERGY

Oil–water interfaces create high interfacial tension and free energy.



3. THERMODYNAMICALLY UNSTABLE

The system is not at equilibrium and tends to reduce interfacial area.



SYSTEM DRIVES TOWARD PHASE SEPARATION TO MINIMIZE INTERFACIAL FREE ENERGY



4. ROLE OF EMULSIFIERS

Emulsifiers adsorb at the interface, lower interfacial tension, and reduce free energy.

They provide **kinetic stability** by forming a protective barrier.



5. KINETIC vs THERMODYNAMIC

Emulsions can be stable for long periods (**kinetic stability**) but are not at the lowest possible energy state (**thermodynamic stability**).

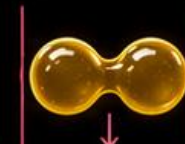
6. INSTABILITY MANIFESTS AS

CREAMING



Droplets rise or sink under gravity (reversible).

COALESCENCE



Droplets merge to form larger droplets.

BREAKING



Complete phase separation into oil and water.



REDUCE INTERFACIAL ENERGY • USE EMULSIFIERS • IMPROVE KINETIC STABILITY • CONTROL INSTABILITY



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42.

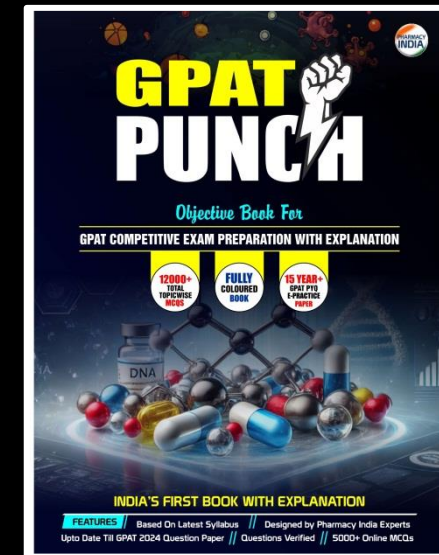
HLB value of O/W

(a) 2–3

(b) 3–6

(c) 7–9

(d) 8–16



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42.

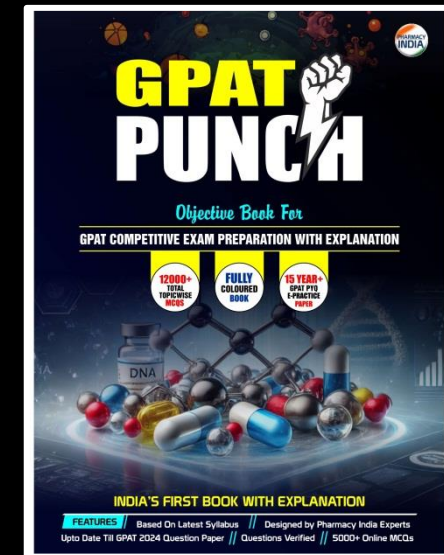
HLB value of O/W

(a) 2–3

(b) 3–6

(c) 7–9

(d) 8–16



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HLB RANGE FOR O/W EMULSIONS



1 O/W NEEDS HYDROPHILIC EMULSIFIERS

Oil-in-water systems require water-loving (hydrophilic) surfactants.



2 PREFERRED HLB RANGE 8–16

Best stability for O/W emulsions.



3 HIGHER HLB = MORE WATER AFFINITY

As HLB increases, emulsifier becomes more hydrophilic.



4 STABILIZES OIL DROPLETS IN WATER

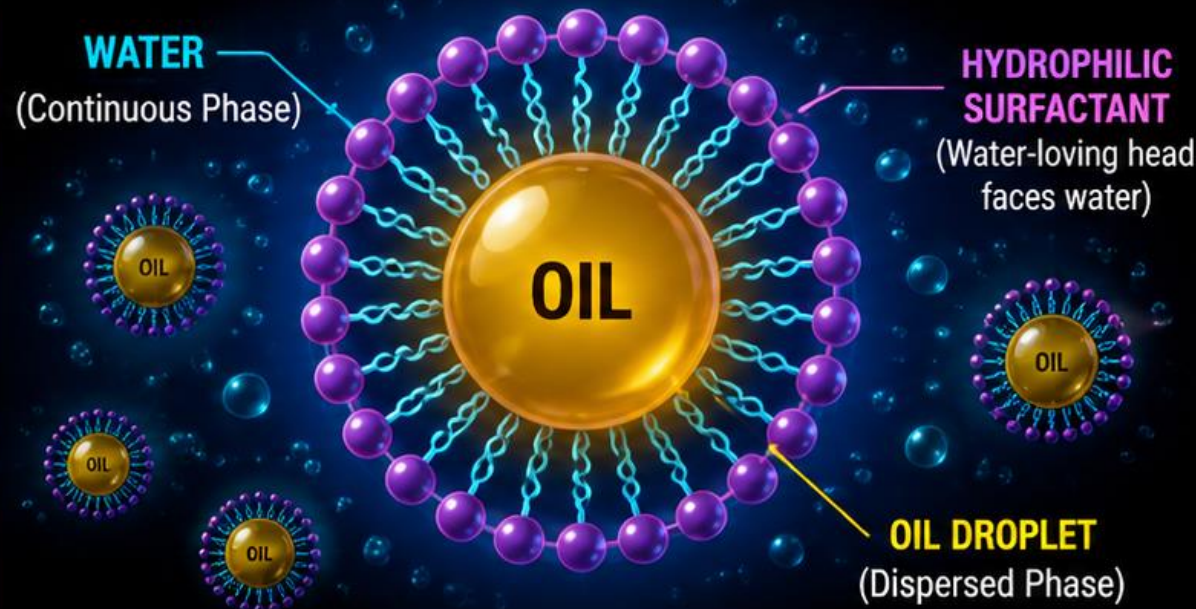
Hydrophilic surfactants form a protective layer around oil droplets and prevent coalescence.



5 COMMON EXAMPLES

Tween 20, Tween 60, Tween 80, Polysorbate 20, 60, 80 (Nonionic Surfactants)

OIL-IN-WATER EMULSIONS



RIGHT HLB → BETTER STABILITY → BETTER PERFORMANCE

WHAT IS HLB?

Hydrophilic–Lipophilic Balance indicates the balance between water-loving and oil-loving properties of a surfactant.



REMEMBER



For O/W emulsions, choose emulsifiers with **HLB 8–16** for maximum stability and effectiveness.

APPLICATIONS



- Creams & Lotions
- Cosmetic Emulsions
- Pharmaceuticals
- Food & Beverages
- Agrochemical Formulations

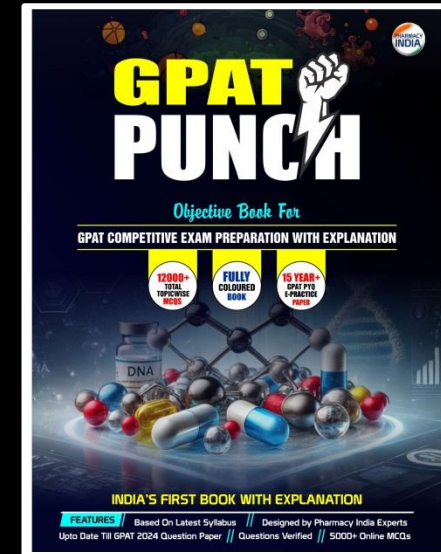


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43.

The density of the dispersed phase is more than that of the dispersion medium. According to Stokes' equation the creaming is

- (a) At the centre of the emulsion
- (b) In both directions
- (c) In downward direction
- (d) In upward direction



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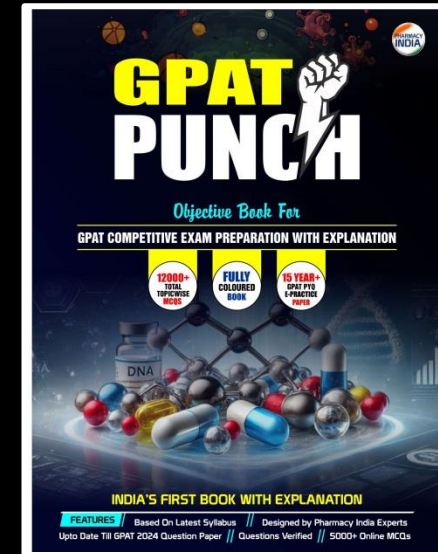
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- (a) At the centre of the emulsion
- (b) In both directions
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DOWNWARD CREAMING BY STOKES' LAW

In an emulsion, when the **dispersed phase is denser** than the continuous phase, droplets **move downward**.



1. DENSER DROPLETS MOVE DOWNWARD

If the dispersed phase is denser than the continuous medium, droplets migrate downward due to gravity.



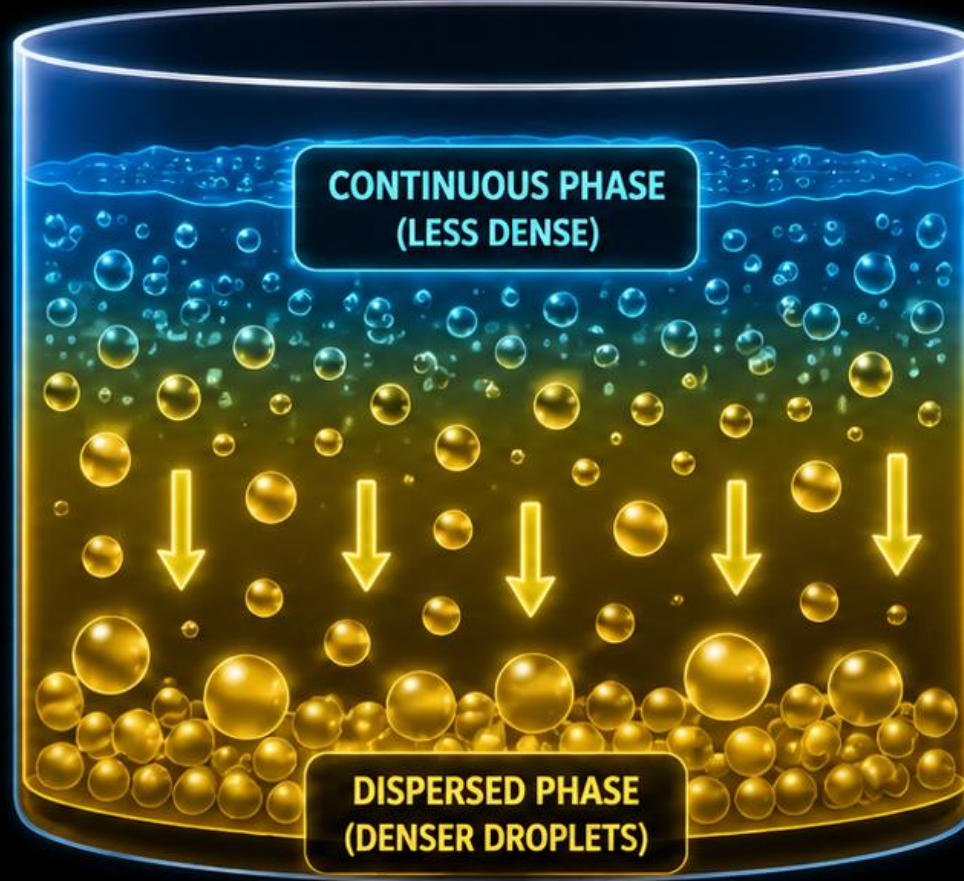
2. STOKES' LAW EXPLAINS THE RATE

Stokes' law describes the terminal velocity of a droplet settling (creaming downward) in a viscous fluid.



3. LARGER DROPLET SIZE INCREASES RATE

Settling velocity is directly proportional to the square of droplet radius ($\propto r^2$).



Net movement: Droplets **move downward** until a compact layer forms.



4. GREATER DENSITY DIFFERENCE INCREASES RATE

Settling velocity is directly proportional to the density difference ($\Delta\rho = \rho_d - \rho_c$).



5. HIGHER VISCOSITY SLOWS MOVEMENT

Settling velocity is inversely proportional to the viscosity of the continuous phase (η).



KEY TAKEAWAY

Downward creaming (sedimentation) occurs when droplets are denser. Rate $\uparrow$ with larger size & higher $\Delta\rho$; Rate $\downarrow$ with higher viscosity.

STOKES' LAW (TERMINAL VELOCITY) $\rightarrow$

$$v = \frac{2r^2(\rho_d - \rho_c)g}{9\eta}$$

WHERE:

v = terminal settling velocity
 r = droplet radius

ρ_d = density of dispersed phase
 ρ_c = density of continuous phase

η = viscosity of continuous phase
 g = acceleration due to gravity

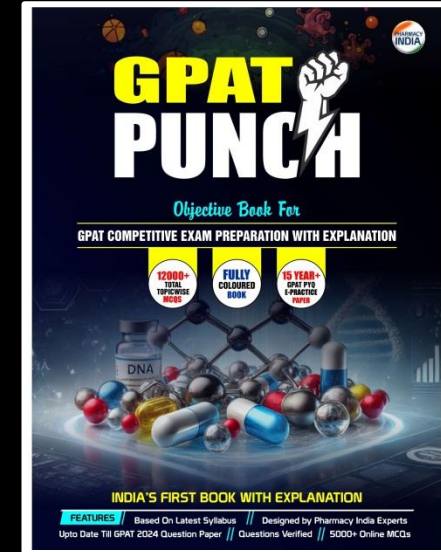


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44.

The HLB range of an emulsifier employed in the preparation of water-in-oil emulsion is

- (a) 3 to 6
- (b) 7 to 12
- (c) 13 to 15
- (d) More than 15



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44.

The HLB range of an emulsifier employed in the preparation of water-in-oil emulsion is

- (a) 3 to 6
- (b) 7 to 12
- (c) 13 to 15
- (d) More than 15



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HLB RANGE FOR W/O EMULSIFIERS



W/O EMULSIONS REQUIRE LIPOPHILIC EMULSIFIERS

They prefer oil over water and have low HLB values.



IDEAL HLB RANGE: 3 – 6

Surfactants in this range are best for W/O emulsions.



LOW HLB = MORE OIL-SOLUBLE

Lower HLB surfactants stay in the oil phase and act at the water-oil interface.

HYDROPHILE-LIPOPHILE BALANCE (HLB) SCALE

More Lipophilic

More Hydrophilic

0

3

6

10

20

W/O Emulsifiers

O/W Emulsifiers

IDEAL RANGE
3 – 6

Water Droplet

Emulsifier Molecules

Oil Continuous Phase

WATER-in-OIL
(W/O) EMULSION



STABILIZES WATER DROPLETS IN OIL

Forms a protective film around water droplets and prevents coalescence.



TYPICAL W/O EMULSIFIERS: SPAN SURFACTANTS

Spans (e.g., Span 20, Span 60, Span 80) are non-ionic, low HLB emulsifiers used in W/O systems.



RESULT

Stable, smooth, and long-lasting W/O emulsions with excellent consistency.

LOW HLB (3–6) = LIPOPHILIC EMULSIFIER = STABLE W/O EMULSION



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45.

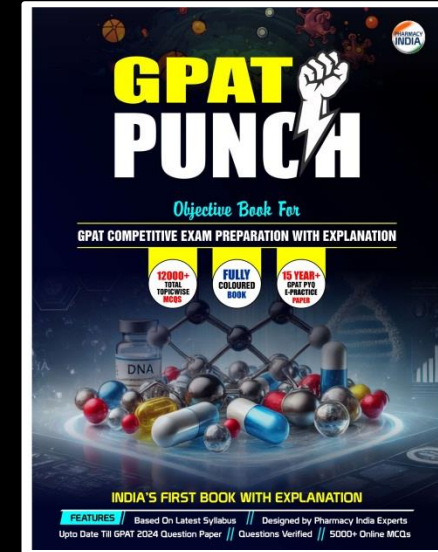
Emulsions are defined as thermodynamically unstable systems. The events that follow sequentially towards instability are

(a) Coalescence → Breaking → Creaming → Flocculation

(b) Coalescence → Flocculation → Creaming → Breaking

(c) Flocculation → Creaming → Breaking → Coalescence

(d) Flocculation → Creaming → Coalescence → Breaking



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45.

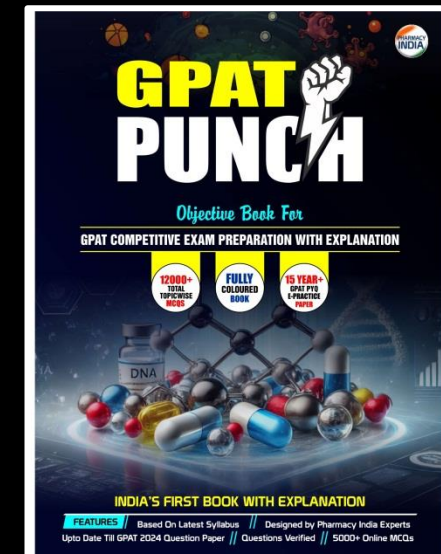
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(a) Coalescence → Breaking → Creaming → Flocculation

(b) Coalescence → Flocculation → Creaming → Breaking

(c) Flocculation → Creaming → Breaking → Coalescence

(d) Flocculation → Creaming → Coalescence → Breaking



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SEQUENCE OF EMULSION INSTABILITY

Emulsion instability occurs in a sequence of steps that lead to complete separation of phases.

1 FLOCCULATION



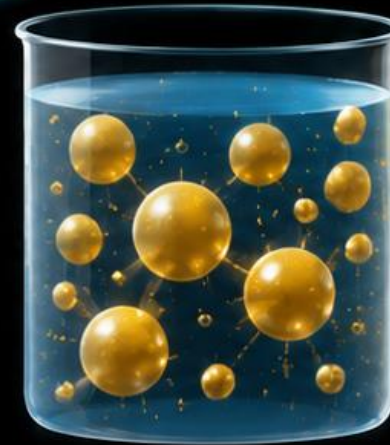
Droplets come together to form loose clusters.

2 CREAMING



Clusters move upward or downward, concentrating one phase.

3 COALESCENCE



Droplets fuse together to form larger globules.

4 BREAKING



Complete separation of oil and water phases.



1. Flocculation forms loose droplet clusters without changing size.



2. Creaming causes upward or downward movement and concentration.



3. Coalescence fuses droplets into larger globules, reducing stability.



4. Breaking is the final stage with complete phase separation.



5. Preventing early instability steps improves shelf life and product quality.



Control the early steps (flocculation & creaming) to maintain a stable emulsion for longer shelf life.



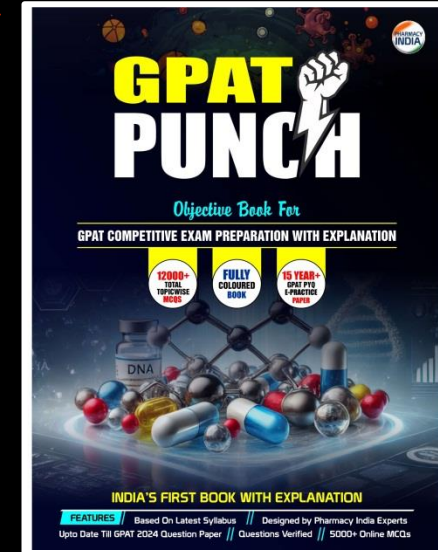
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46.

Creaming is a _____ process

- (a) Reversible
- (b) Irreversible
- (c) Both
- (d) None of the above



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46.

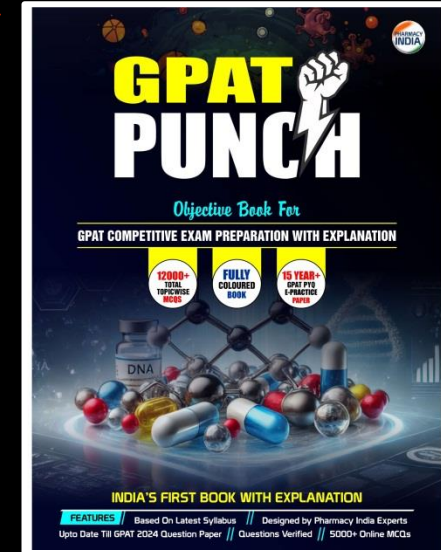
Creaming is a _____ process

(a) Reversible

(b) Irreversible

(c) Both

(d) None of the above



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CREAMING IS REVERSIBLE

Creaming is a Physical, Not a Permanent Change

1. DROPLET MIGRATION



Creaming occurs when dispersed droplets move upward due to density difference. No fusion occurs.

2. DROPLETS REMAIN INTACT



Droplet size and identity remain unchanged during creaming.

3. NO PERMANENT SEPARATION



The continuous phases do not separate. System remains an emulsion.



4. GENTLE SHAKING REDISTRIBUTES



Light shaking breaks the creamed layer and redistributes droplets evenly.

5. THEREFORE, REVERSIBLE



Since no permanent change occurs, creaming is fully reversible.

6. DIFFERENT FROM BREAKING



Breaking is irreversible; droplets coalesce and phases separate permanently.



Creaming is Droplet Movement, **Not Destruction.**
— A gentle shake brings it back! —



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47.

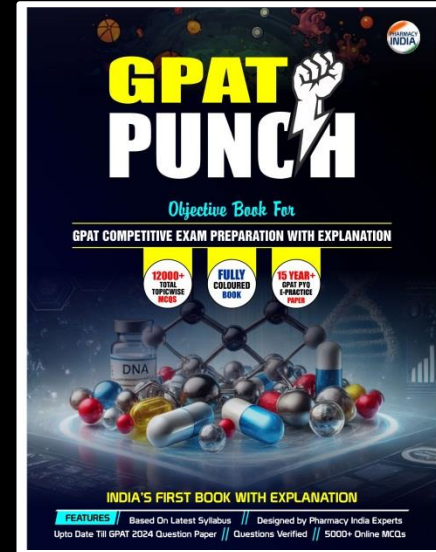
O/W emulsions normally cream

(a) Up first & down then

(b) Upward

(c) Downward

(d) None of the above



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47.

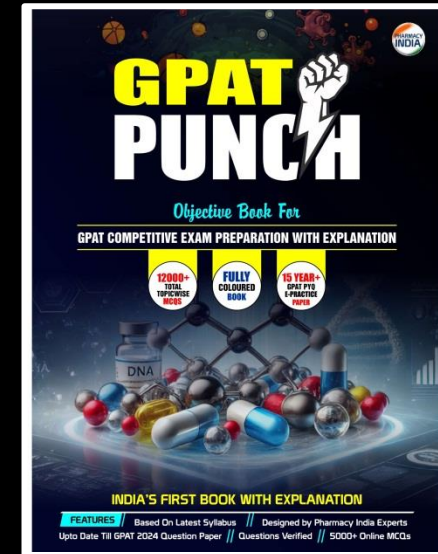
O/W emulsions normally cream

(a) Up first & down then

(b) Upward

(c) Downward

(d) None of the above



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UPWARD CREAMING IN O/W EMULSIONS



1. OIL DROPLETS ARE LIGHTER

In most O/W emulsions, oil droplets are less dense than water.



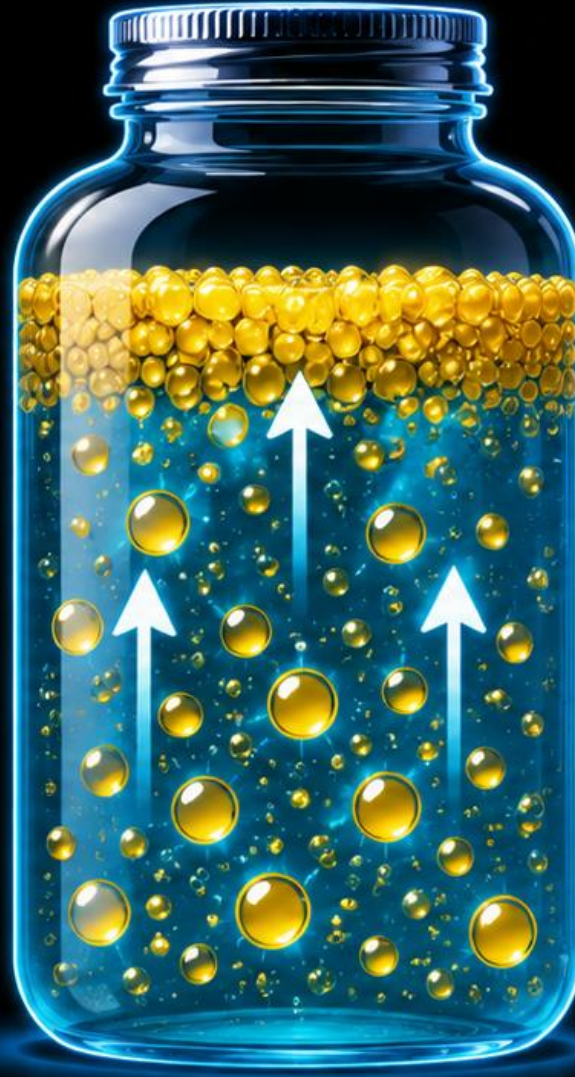
2. DROPLETS RISE TO THE TOP

Due to buoyancy, oil droplets move upward through the water phase.



3. UPPER CREAM LAYER IS FORMED

Oil droplets accumulate at the top, forming a concentrated cream layer.



4. CALLED UPWARD OR POSITIVE CREAMING

This type of creaming is known as upward or positive creaming.



5. SMALLER DROPLETS REDUCE RATE

Smaller oil droplets rise more slowly, reducing the creaming rate.



6. HIGHER VISCOSITY REDUCES RATE

Increasing viscosity of the continuous phase slows down upward creaming.



KEY POINT: Upward creaming is a natural process in O/W emulsions due to density difference. It can be controlled by reducing droplet size and increasing continuous phase viscosity.





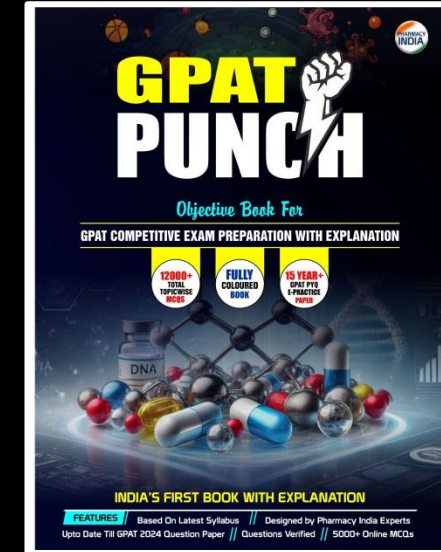
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48.

Downward creaming means _____ rate of sedimentation

- (a) Negative
- (b) Positive
- (c) Same
- (d) Difficult to predict



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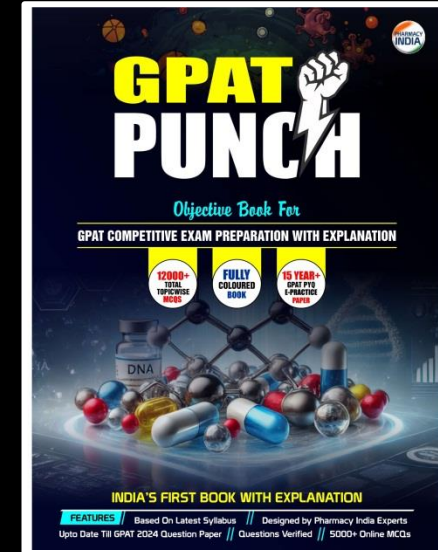
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48.

Downward creaming means _____ rate of sedimentation

- (a) Negative
- (b) Positive
- (c) Same
- (d) Difficult to predict



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NEGATIVE SEDIMENTATION IN DOWNWARD CREAMING

A TYPE OF INSTABILITY IN EMULSIONS WHERE DROPLETS SETTLE DOWNWARD



1. DOWNWARD CREAMING

Droplets move toward the bottom of the container over time.



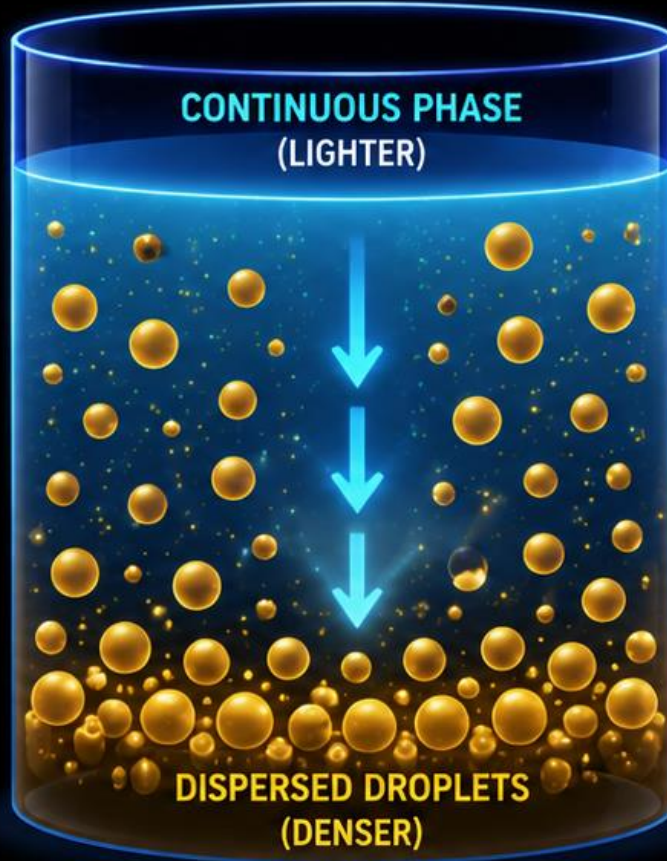
2. DENSITY CONDITION

Occurs when dispersed droplets are denser than the continuous medium.



3. NEGATIVE RATE

The sedimentation rate is considered negative because movement is downward.



TOP

BOTTOM

NEGATIVE SEDIMENTATION RATE ($v_s < 0$)

Negative sign indicates downward movement.



4. OPPOSITE TO UPWARD CREAMING

Downward creaming is the reverse of upward creaming.



5. FACTORS AFFECTING RATE

- Higher viscosity of the continuous phase decreases the rate.
- Larger droplet size increases the rate.



6. PRACTICAL IMPACT

Can lead to sediment formation, phase separation, and reduced product stability.



KEY IDEA: Droplets are heavier than the medium → They cream **downward** → Sedimentation rate is **negative**.



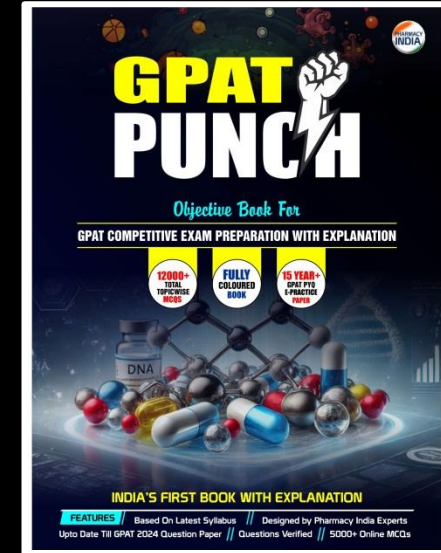
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49.

Which one of the following emulsifier is used to stabilise the emulsion of W/O type?

- (a) SLS
- (b) Span 20
- (c) Tween 20
- (d) Tragacanth



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49.

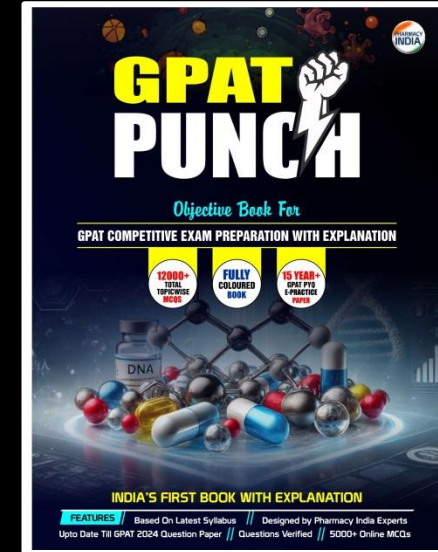
Which one of the following emulsifier is used to stabilise the emulsion of W/O type?

(a) SLS

(b) Span 20

(c) Tween 20

(d) Tragacanth



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SPAN 20 FOR W/O EMULSIONS

1

SPAN 20 IS A
LOW-HLB
NONIONIC SURFACTANT



2

LOW HLB
FAVORS
WATER-IN-OIL
EMULSIONS



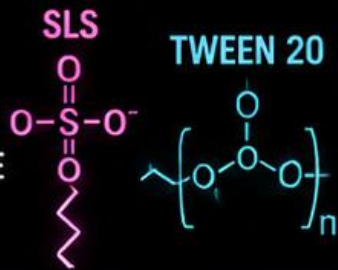
3

IT STABILIZES
WATER DROPLETS
IN AN OIL
CONTINUOUS PHASE

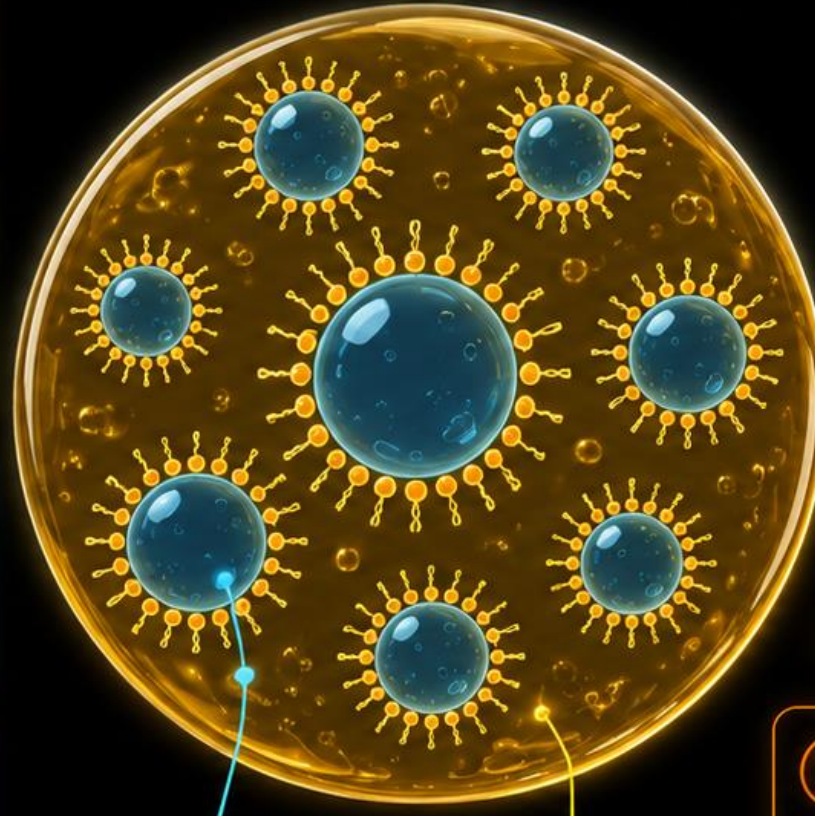


4

HYDROPHILIC
SURFACTANTS
SUCH AS SLS OR
TWEEN 20 ARE MORE
SUITABLE FOR O/W
SYSTEMS



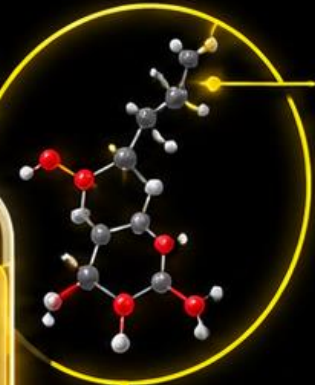
WATER-IN-OIL (W/O) EMULSION



WATER
DROPLET

OIL
CONTINUOUS
PHASE

SPAN 20



LIPOPHILIC
(OIL-LOVING)
LAURIC CHAIN

HYDROPHILIC
SORBITAN HEAD

5

EMULSIFIER CHOICE
DEPENDS ON

- ✓ HLB VALUE
- ✓ EMULSION TYPE
- ✓ APPLICATION REQUIREMENT



SPAN 20 (LOW HLB) → STABILIZES WATER DROPLETS IN OIL → IDEAL FOR W/O EMULSIONS



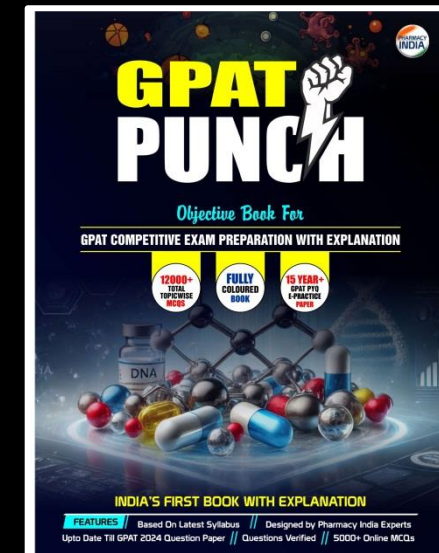
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50.

In the stability of emulsion which important instability step should be prevented?

- (a) Breaking
- (b) Coalescence
- (c) Flocculation
- (d) Creaming



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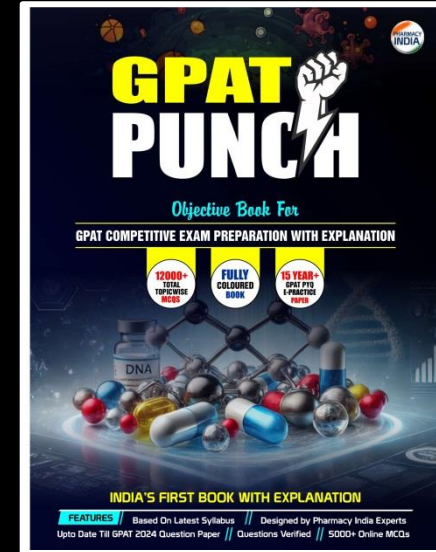


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50. In the stability of emulsion which important instability step should be prevented?

- (a) Breaking
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- (c) Flocculation
- (d) Creaming



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PREVENT COALESCENCE TO PRESERVE EMULSION STABILITY

STOP DROPLETS FROM MERGING, KEEP EMULSIONS STABLE



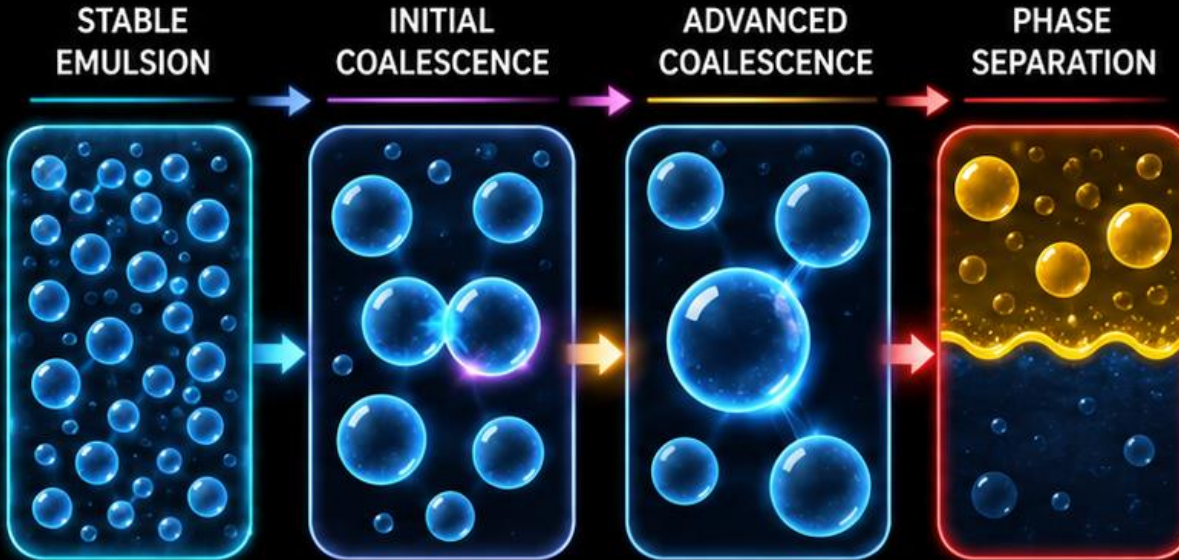
1 COALESCENCE IS
FUSION OF DROPLETS
INTO LARGER
GLOBULES.



2 IT REDUCES TOTAL
DROPLET NUMBER
AND ENLARGES
DROPLET SIZE.



3 CONTINUED
COALESCENCE
LEADS TO BREAKING
OF THE EMULSION.



4 FLOCCULATION AND
CREAMING MAY BE
REVERSIBLE,
BUT COALESCENCE
IS A MAJOR HARMFUL
INSTABILITY STEP.



5 PREVENTING
COALESCENCE
IS ESSENTIAL
TO MAINTAIN
EMULSION
STABILITY.

! COALESCENCE = PATHWAY TO PHASE SEPARATION !

CONSEQUENCES OF UNCONTROLLED COALESCENCE



Loss of
Stability



Poor Product
Performance



Changes in
Appearance



Reduced
Shelf Life



Economic
Loss



HOW TO PREVENT
COALESCENCE

- Use effective emulsifiers
- Provide steric/electrostatic barrier
- Increase continuous phase viscosity
- Optimize formulation & process



STOP COALESCENCE. PRESERVE DROPLETS. ENSURE STABILITY.





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YOU!



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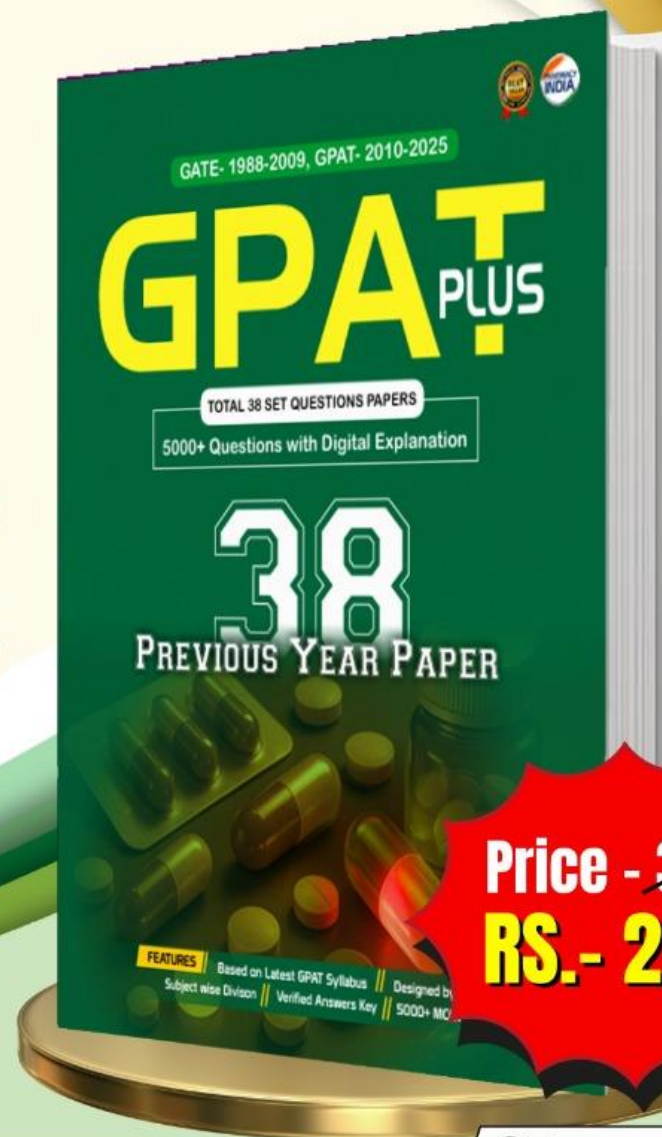
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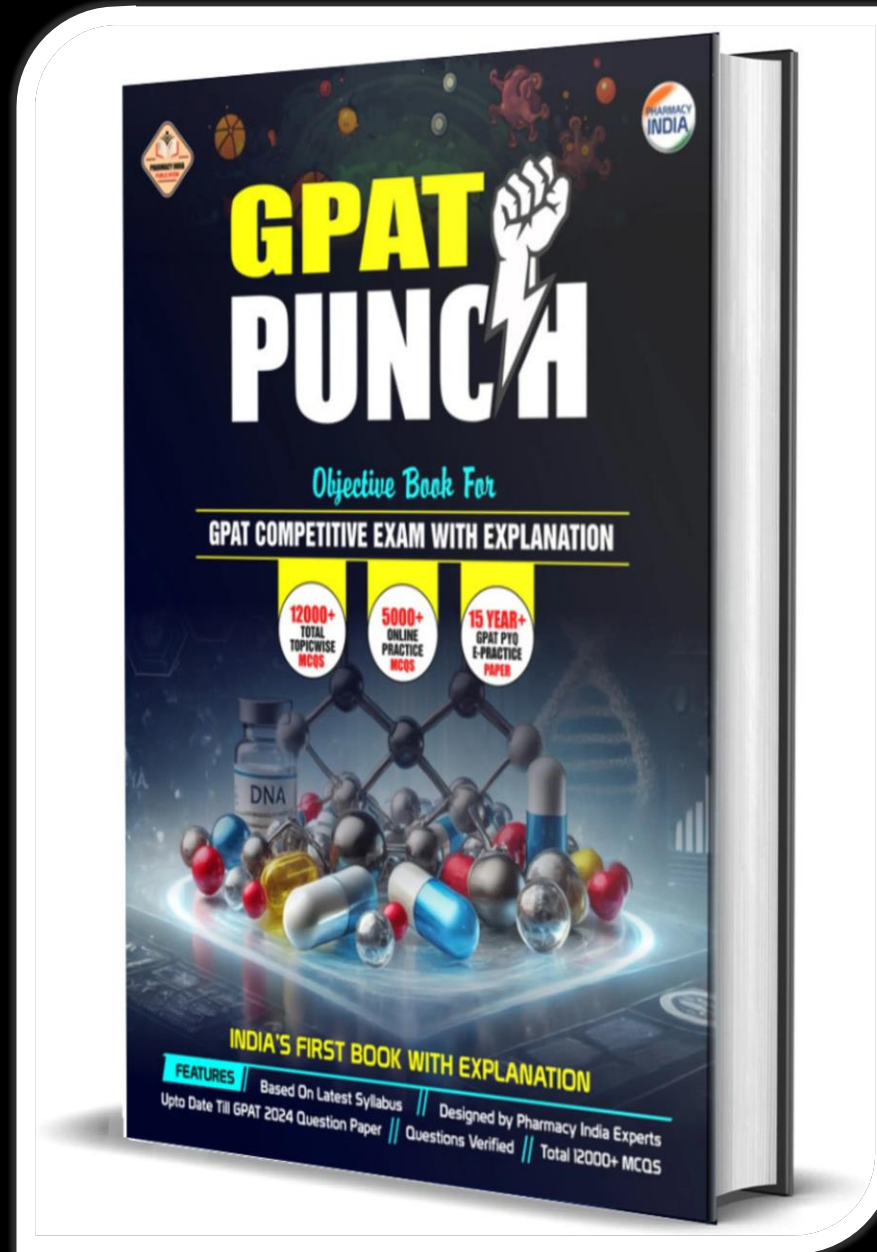


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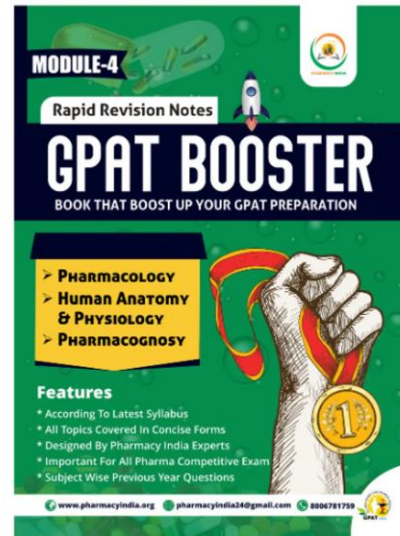
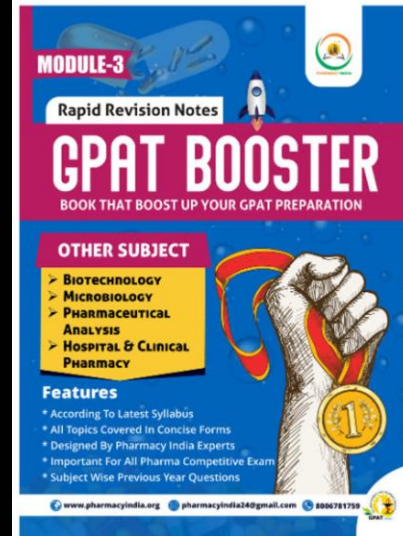
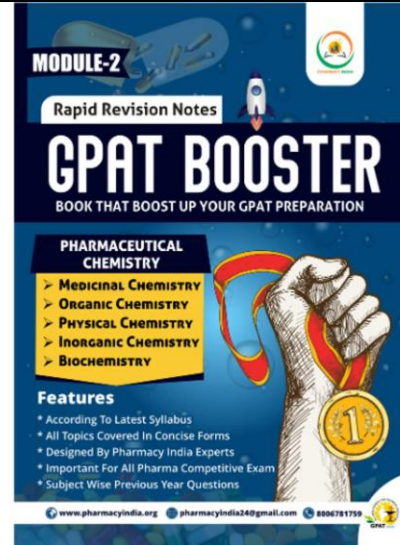
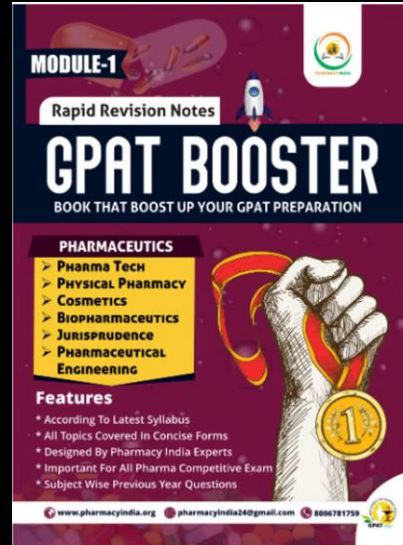
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