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Subject: Physical Pharmacy (BP-403T)

Unit: IV

Topic: Particle shape, methods for determining surface area, Derived properties of powder & Flow properties.

II. Particle Shape Determination

- Particle shape also has influence on surface area, flow properties, packing and compaction of the particles.

- Spherical particles have minimum surface area and better flow properties.

- Shape can also have influence on rate of dissolution of drugs.

- Techniques of determination are:
  - ✓Microscopy *(refer in particle size determination)*
  - ✓Light scattering

Particle Shape

- Acicular – needle-shaped
- Angular – sharp-edged
- Crystalline – geometric shape
- Dendritic – branched crystalline shape
- Granular equidimensional irregular shape
- Spherical – global shape

III. Surface Area Determination

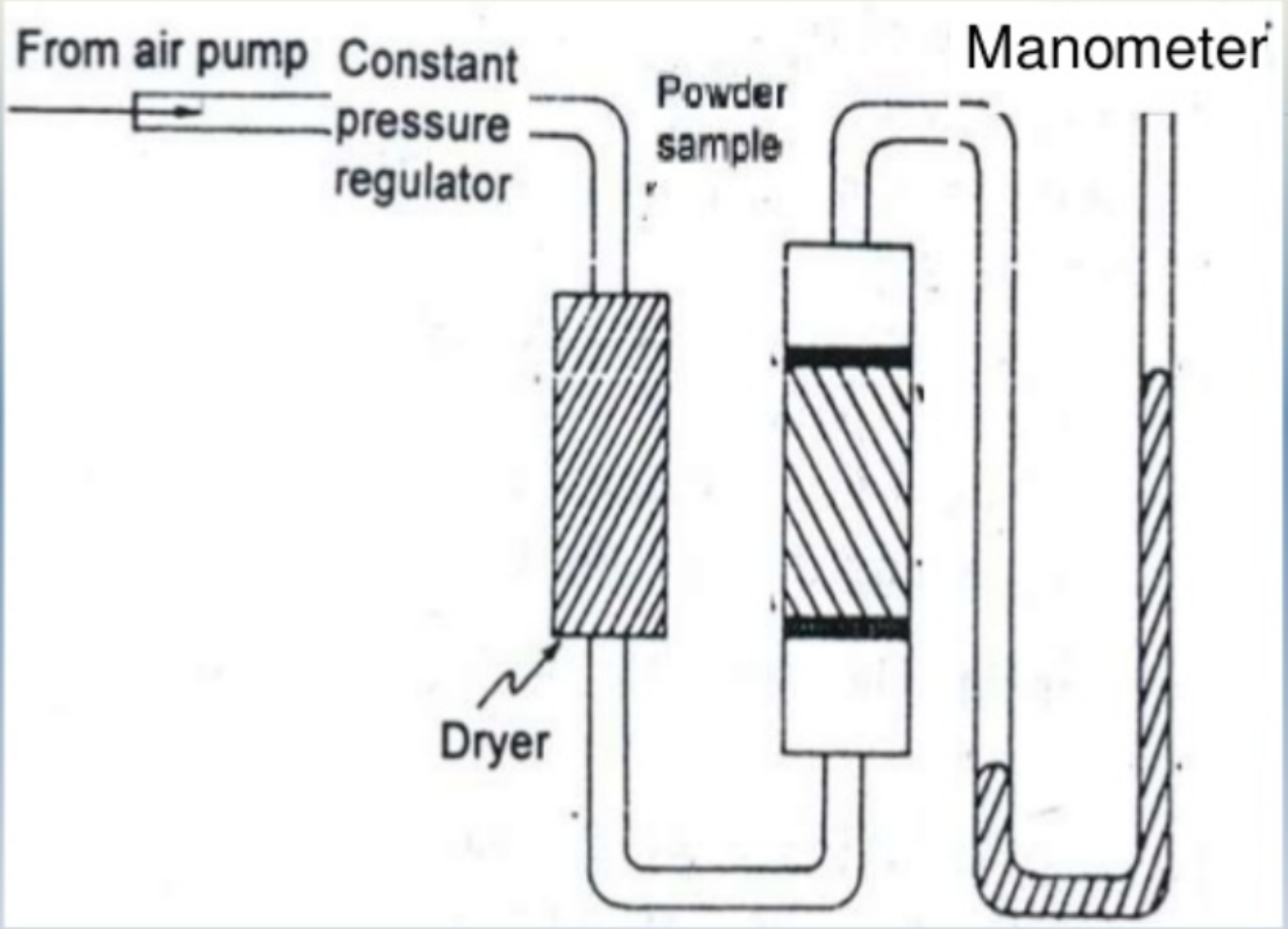
1. Adsorption method:

- **Surface area** is most commonly determined based on **Brunauer-Emmett-Teller (BET)** theory of adsorption.
- Most substances adsorb a monomolecular layer of gas under certain conditions of partial pressure of gas and temperature.
- The adsorption process is carried out **at liquid nitrogen temperatures -196°C.**
- Once surface adsorption has reached equilibrium, the sample is heated at RT and Nitrogen gas is desorbed. Its volume is measured.
- As each N_2 mol. occupies fixed area, one can compute surface area of pre-weighed sample.

Surface Area Determination

2. Air Permeability method:

- Powder is packed in sample holder
- Packing appears as series of capillaries
- Air is allowed to pass through the capillaries at constant pressure
- Resistance is created as air passes through capillaries thus causing pressure drop.
- Greater the surface area greater the resistance
- Air permeability is inversely proportional to the surface area


From air pump
Constant
pressure
regulator
Powder
sample
Manometer
Dryer

- **Surface area** of a powder can be calculated using particle size data obtained from any suitable method.
- Specific surface area i.e. surface area per unit weight (S_w) or unit volume (S_v) can be estimated as follows:
- $S_v = \frac{\text{surface area of particles}}{\text{volume of particles}}$
- $S_v = \frac{\text{no. of particles x surface area of each particle}}{\text{no. of particles x volume of each particle}}$

Surface area is an important parameter as the bioavailability of certain drugs is dependant on surface area. eg. Bephenium (anthelminitic), Griseofulvin (anti-fungal)- if the surface area is less than specified, the absorption decreases.

Derived properties of powders

- Size or diameter is a fundamental property of a particle.
- Volume, density, porosity etc. are the properties derived from fundamental properties.
- e.g. Volume can be calculated from the diameter of the particle ($4/3\ \pi r^3$).
- However, derived properties can also be calculated without the use of fundamental properties.

DENSITY

- **Apparent bulk density- is determined by pouring presieved (40#) bulk drug into a** graduated cylinder via a funnel and note the volume as is (g/ml) *without subjecting to any external force.*

- **Tapped density:** The cylinder is subjected to fixed no. of taps on a mechanical tapper apparatus (approx. 100) until the powder bed has reached minimum.

  (useful for determining the appropriate size for capsule formulation)

Bulk Density Apparatus

Bulk density

$$= \frac{\text{Mass of the powder}}{\text{Bulk volume}}$$

Tapped bulk density

$$= \frac{\text{Mass of the powder}}{\text{Tapped Bulk volume}}$$

Applications

- Decides the size of the capsule based on bulk and tapped volume of a given sample
  - Higher the bulk volume, lower the bulk density and bigger the size of the capsule
- Helps to decide proper size of a container or packing material

- Light powders
  - When particles packed loosely
  - Lots of gaps between particles
  - Bulk volume increases
- Light powders have high bulk volume
  - hence low density

DENSITY

- **True density**: Volume occupied by voids (inter-particle spaces) and intraparticle pores are not included in this measurement.
- Calculated by suspending drug in solvents of various densities & in which the compound is insoluble.
- After vigorous agitation, samples are centrifuged briefly, and then left to stand undisturbed till settling/ flotation has reached equilibrium. The sample that remains suspended corresponds to the true density of the material. Calculated with a pycnometer.

TRUE DENSITY DETERMINATION

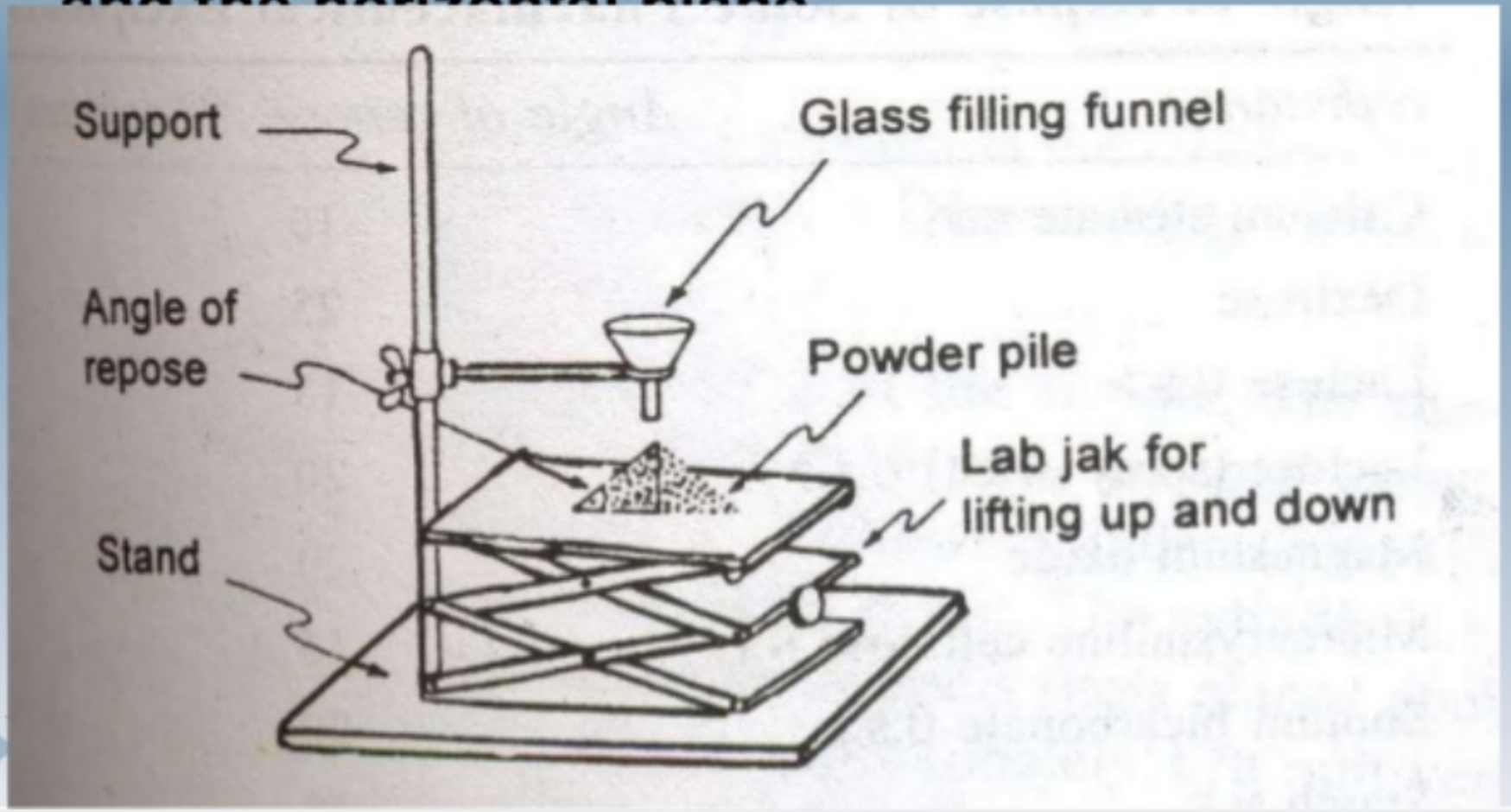
- Helium displacement method (for porous powders)
- Liquid displacement method (for non porous powders)

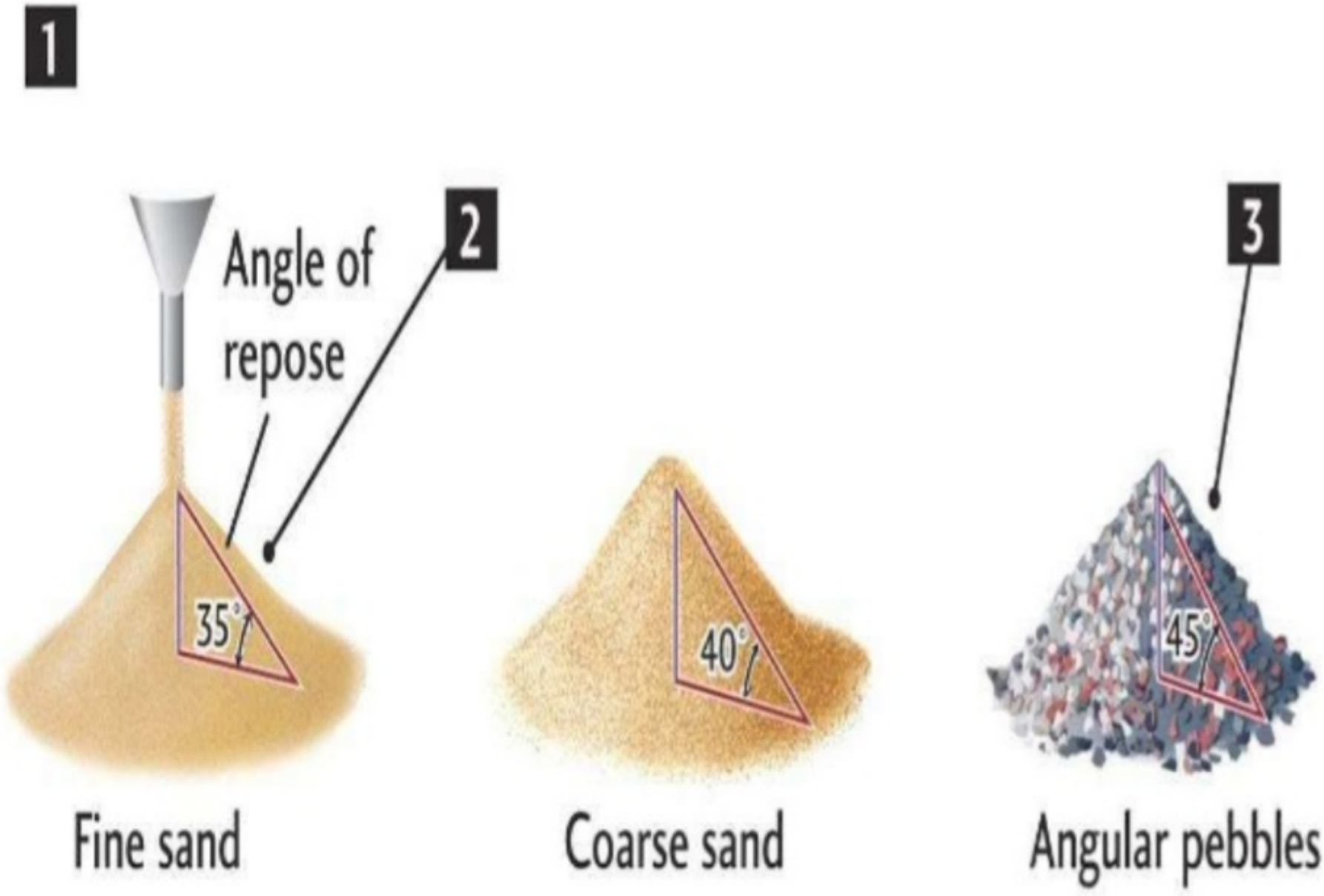
Powder flow properties

- P'ceutical powders may be broadly classified as free-flowing or cohesive.
- Most flow properties are significantly affected by changes in **particle size, density, electrostatic charges, adsorbed moisture**.
- Good flow property is required for easy and uniform flow from hopper to die cavity ensuring accurate weight and dose.

Angle of repose is calculated for estimating flow properties.

It is defined as the maximum angle possible between the surface of a pile of the powder and the horizontal plane




1
Angle of repose
2
35°
40°
3
45°
Fine sand
Coarse sand
Angular pebbles

Powder flow properties estimation

- Simple flow rate apparatus consisting of a metal tube from which drug flows through an orifice onto an electronic balance, which is connected to a recorder.
- **Angle** of **repose** determination using **reposograph**

- Another method is % compressibility **(Carr's index)**

$$= \frac{\textbf{(bulk volume- tapped volume) x 100}}{\textbf{bulk volume}}$$

Hausner's ratio = tapped density/ Bulk density

Or

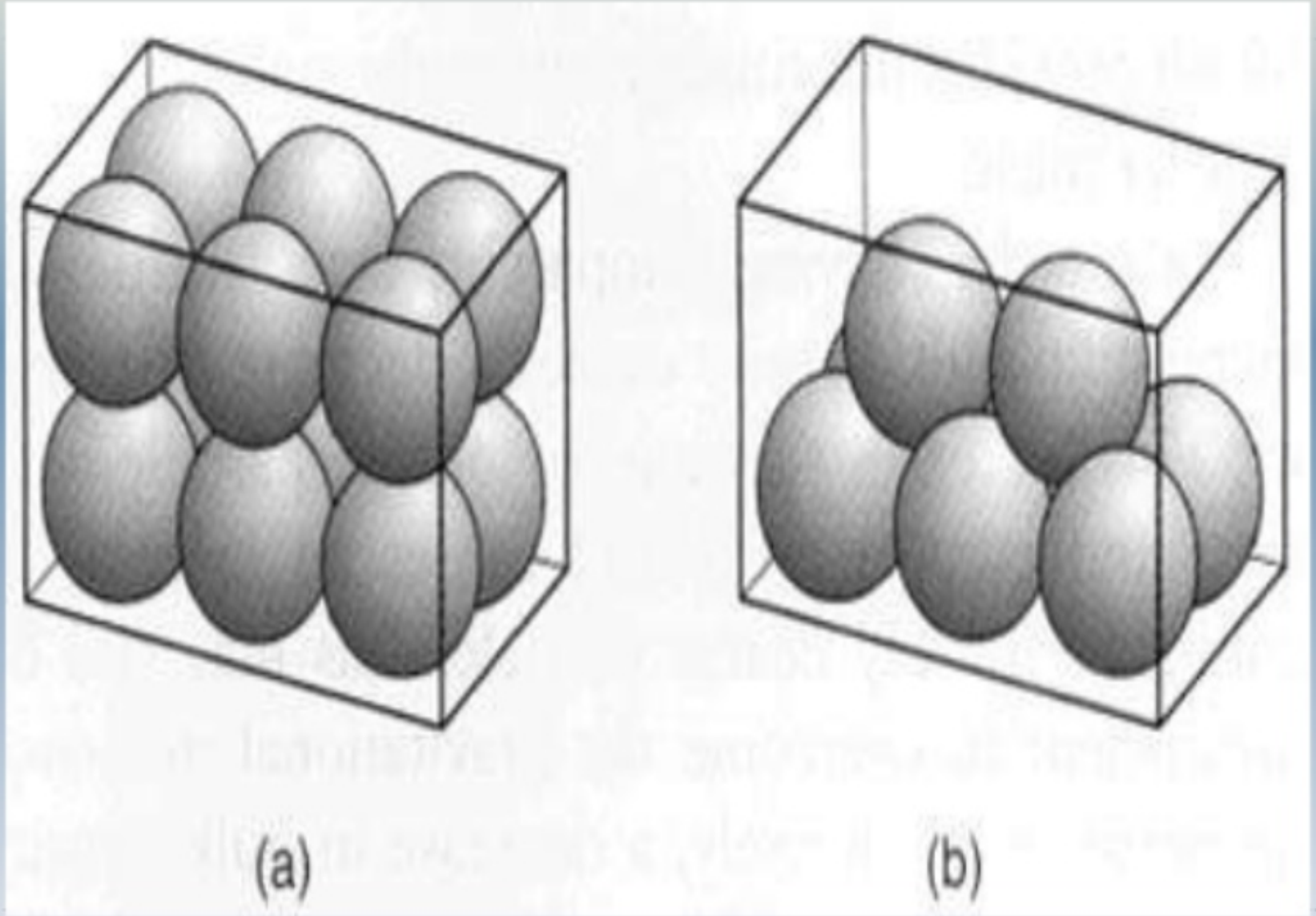
Bulk volume/ tapped volume

Packing properties (Porosity)

- ***Porosity definition:*** ***It is the ratio of the volume of voids between particles, plus the volume of pores, to the total volume occupied by the powder, including voids and pores.***
- A set of particles can be filled into a volume of space in different ways.
- This is because by slight vibration, particles can be mobilized and can occupy a different spatial volume than before.
- This changes the bulk volume because of rearrangement of the packing geometry of the particles.
- In general, such geometric rearrangements result in a transition from loosely packed particles to more tightly

Packing properties (Porosity)

- Example: : A set of monosized spherical particles can be arranged in many different geometric configurations.
- In Fig.a, when the spheres form a cubic arrangement, the particles are most loosely packed and have a porosity of 48%
- In Fig.b, when the spheres form a rhombohedral arrangement, they are most densely packed and have a porosity of only 26%
- The porosity used to characterize packing geometry is linked to the bulk density of the powder.
- .


(a)
(b)

Packing properties (Porosity)

- Thus bulk density, is a characteristic of a powder rather than individual particles and can be variable.
- The bulk density of a powder is always less than the true density of its component particles because the powder contains interparticle voids.
- **Thus, powder can possess a single true density but can have many different bulk densities, depending on the way in which the particles are packed and the bed porosity.**

Powder fluidization

- Fluidization can be a highly effective method for **handling a fine bulk material** in an aerated or liquid-like condition. Air or another gas can be used for powder fluidization either in a fully fluidized state or only in a localized manner with small amounts of gas flow.
- Typical bulk solids suitable for fluidization have a fine particle size, a low permeability, and low cohesive strength.

Advantages:

- Elimination or reduction of poor flow problems of powder, Increased discharge rate from hopper
- Reduction in mixture segregation

Density (ρ): density is universally defined as weight per unit volume.

Three type of densities can be defined

True density

Granule density

Bulk density

Bulkiness : Specific bulk volume ,the reciprocal of bulk density, it is often called bulkiness or bulk.

Bulkiness increase with a decrease in particle size .

Flow properties : powder may be free flowing or cohesive.

Factors that

affect the Flow properties are particle size , shape , surface

texture, porosity and density.

Angle of repose (ϕ) have been used as indirect method for quantifying

powder flowability.

$$\phi = \tan^{-1}(h/r)$$

Here: h = height of pile

r = radius of pile