CENTRIFUGATION

- If the amount of sediment is too small or the particles are small and light, the filtration process is insufficient. In such cases, centrifugation is performed to allow the precipitate from the liquid phase.
- **The main purpose** is to apply a centrifugal force of magnitude that exceeds the gravitational force to ensure that the particles are compacted to the bottom of the centrifuge tube.

Sedimentation by Gravity

A particle suspended in a liquid medium of lesser density tends to sediment downward due to the force of gravity, F_g.

Newton showed that an object is accelerated by the gravitational force according to the relation:

$$F_g = m\, g = m \times 980\ cm\ s^{-2}$$

m = the mass of the object

g = the acceleration due to gravity

- In an idealized case of a free-falling object being accelerated by gravity in a vacuum, the velocity of the object would exhibit a uniform rate of increase.
- However, for a real-world case of an object falling through air, or settling in a liquid medium, there are two forces that oppose the gravitational force; the buoyancy force, F_b, and the frictional force, F_f.

Buoyancy Force

Archimedes showed that a particle suspended in a fluid experiences an upwards force that is equivalent to the weight of the fluid displaced:

$$F_b = m_M g = V_P \rho_M g$$

m_M = the mass of the fluid medium displaced

V_p = the volume of the particle (volume of the displaced fluid)

ρ_M = the density of the displaced fluid

Frictional Force

The movement of a particle through a fluid medium is hindered by the viscosity of the medium, η, as described for a spherical particle by Stokes' equation:

$$F_f = 6\pi\eta r(dx/dt)$$

η = the viscosity of the medium in poise P (g cm^{-1} s^{-1})

r = the radius of the particle (cm)

(dx/dt) = the velocity of the moving particle (cm s^{-1})

Diffusion

Random Brownian motion results in the net movement of solute or suspended particles from regions of higher concentration to regions of lower concentration, a process called **diffusion**.

- **Brownian motion**: the erratic random movement of microscopic particles in a fluid, as a result of continuous bombardment from molecules of the surrounding medium.

Sedimentation in a Centrifugal Field

A particle moving in a circular path continuously experiences a centrifugal force, F_c. This force acts in the plane described by the circular path and is directed away from the axis of rotation. The centrifugal force may be expressed as:

$$F_c = ma = m\omega^2 x$$

m = the particle mass (g)

a = the acceleration (cm s^{-2})

ω = the angular velocity (radians s^{-1} =2π rpm/60)

x = the radial distance from the axis of rotation to the particle (cm).

- Within the centrifugal plane, the centrifugal force acts to move particles away from the axis of rotation.
- The buoyancy and frictional forces oppose this movement.
- The effect of the Earth's gravity can generally be regarded as negligible.
- Analogous to the conditions for attaining terminal velocity in a gravitational field, the particle will reach a limiting or terminal velocity in a centrifugal field when the sum of the frictional and buoyancy forces equals the centrifugal force.