9.7 CENTRIFUGATION

The centrifuge is a widely used instrument in clinical laboratories for the separation of components. Various quantities are used for the description and the calculation of the separation processes at centrifugation. The following list of quantities and units is consistent with SI and ISO rules. See also the corresponding sections of Chapter 1.

Acceleration ($\boldsymbol{a}$, m s^{-2})

Rate of change of velocity. $\boldsymbol{a}$=d$\boldsymbol{v}$/dt. Acceleration is a vector quantity.

Acceleration of free fall (g, m s^{-2})

Acceleration at a free fall in vacuo due to gravity. Acceleration of free fall is a vector quantity.

Avogadro constant (L, N_A; mol^{-1})

Number of entities in a system divided by the amount of substance of these entities. $L = N/n$ = 6,022 1367 10^{-23} mol^{-1}

Boltzmann constant (k; J K^{-1})

Molar gas constant divided by the Avogadro constant $k = R/L$ = 1.380 658 10^{-23} J K^{-1}

Centrifugal acceleration (a_{rot}; m s^{-2})

Acceleration of a component as a result of a uniform rotational motion. Centrifugal acceleration is a vector quantity.

Centrifugal force (F_{rot}; N)

Force acting on a body as a result of centrifugal acceleration, $F_{rot} = m\ a_{rot}$. Centrifugal force is a vector quantity. The centrifugal force equals the product of mass and the centrifugal acceleration of the body. The name of the SI unit for centrifugal force is a newton.

Centrifugal radius (r, m)

Radius at which a component is spinning at the end of the period of centrifugation. For a component sedimented from a dilute suspension, it can be equated with radius of rotation at the bottom of the centrifuge tube.

Circular frequency (ω; s^{-1})

2π times the frequency. $\omega = 2\pi f$

Diffusion coefficient (of component B) (D_B; m^2 s^{-1})

Absolute value of the product of local number concentration of the component and local average velocity of particles of that component divided by number concentration gradient in the direction of movement. $D_B = |C_B v_B|/\text{grad}C_B$

Force (acting on a body) (F, N= kg m s^{-2})

See sections 1.3.2 and 9.6.

Kinetic energy (of a body in uniform motion) (E_k; J= kg m^2 s^2)

Half of the product of mass and square of velocity of the body
$E_k = 1/2\ m\ v^2$. The name of the SI unit for kinetic energy is joule.

Mass concentration (of component B) (γ_B, ρ_B; kg m^{-3})

Mass of the component divided by the volume of the system

$$\gamma_B = m_B/V.$$

Mass density (ρ; kg m^{-3})

Mass of the system divided by its volume $\rho = m/V$.

Mass density gradient (gradρ; kg m^{-4})

Differential change of mass density with distance in direction
x. $\text{grad}_x\rho = \text{d}\rho/\text{d}x$. Colloidal components may be fractionated by centrifugation in a fluid with a gradient obtained by a suitable solute, for instance potassium bromide in water. Mass density gradient is a vector quantity.

Mass fraction (of component B) (w_B; 1)

Mass of the component divided by mass of all components in the system. $w_B = m_B/\Sigma m_i$.

Molar gas constant (R; J K^{-1} mol^{-1})

Universal constant of proportionality in the ideal gas law: $p\ V_m = R\ T$. R = 8,314 511 J K^{-1} mol^{-1}. The gas constant equals the product of the Avogadro constant and the Boltzmann constant. (See 1.5)

Molar mass (of component B) (M_B; kg mol^{-1})

Mass of the component divided by its amount of substance $M_B = m/n_B$.

Molar volume (of component B) ($V_{m,B}$; m^3 mol^{-1})

Volume of the component divided by its amount of substance,

$$V_{m,B} = V/n_B.$$

Moment of inertia (of a body about n axis) (I; kg m^2)

Sum (or integral) of the products of the mass elements of a body and the squares of their respective distances from the axis $I=\Sigma m_i r_i^2$.

Number concentration (of component B) (C_B; m^{-3})

Number of entities of stated type for that component divided by the volume of the system, $C_B = N_B/V$.

Note: Besides molecules or particles, the type of entity may, for instance, be a chemical group within molecules or an ionic charge, and is therefore broader than the kind-of-quantities "molecular concentration" and "particle concentration".

Number concentration gradient (of component B) (gradC_B; m^{-4})

Differential change of number concentration of component B with distance in direction x, $\mathrm{grad}_x C_B = \mathrm{d}C_B/\mathrm{d}x$. Number concentration gradient is a vector quantity.

Partial mass density (of component B) (ρ_B; kg m^{-3})

Change in mass of the component due to addition of a differentially small amount of that component, divided by the change in volume of the system, $\rho_B = \mathrm{d}m_B/\mathrm{d}V$.

Partial specific volume (of component B) (v_B; m^3 kg^{-1})

Change in volume of a system when a differentially small amount of a component is added, divided by the mass of that component, $v_B = \mathrm{d}V/\mathrm{d}m_B$.

Note: Partial specific volume is used in estimation of molar mass of colloidal particles (e.g. viruses or nucleic acids) from the sedimentation coefficient.

Pressure (p; Pa = N m^{-2} = kg s^{-2} m^{-1})

Force divided by area, $p = F/A$. The name of the SI unit for pressure is pascal

Rate coefficient (of a suspended component B in a fluid) (k_B; s^{-1})

Number fraction of particles of the component passing a given position in the direction of gravitational or centrifugal acceleration, divided by time of passage, $k_B = -\mathrm{d}N_B/(N_B \mathrm{d}t) = -(\mathrm{dln}N_B)/\mathrm{d}t$.

Rotational frequency (f_{rot}; Hz = s^{-1})

Number of rotations divided by time, $f_{rot} = dN/dt$. The synonyms: *rate of rotation, rate of revolution, centrifugal speed, centrifugation speed*, and the traditional units of rotational frequency such as *revolutions per minute, r.p.m., rev./min, r/min*, are not recommended. The name of the SI unit for rotational frequency is hertz.

Sedimentation coefficient (or a suspended component B is a fluid) (s_B; s)

Reciprocal of the rate coefficient of the component passing a given position in the direction of gravitational or centrifugal acceleration, $s_B = (k_B)^{-1} = -N_B dt/dN_B = -dt/d\ln N_B$. Use of the "Svedberg unit", Sv = 10^{-13} s, is not recommended.

In current usage, subscripts are added to the symbol to indicate temperature and medium, and superscripts to indicate concentration.

Sedimentation velocity (of a suspended component B in a fluid) (v_B; m s^{-1})

Velocity of the component relative to the fluid in the direction of gravitational or centrifugal acceleration, $v_B = dl_B/dt$. Sedimentation velocity is a vector quantity.

Specific volume (v; m^3 kg^{-1})

Volume of a system divided by its mass, $v = V/m = \rho^{-1}$. Specific volume is the reciprocal of mass density.

Standard acceleration of free fall (g_n; m s^{-2})

Acceleration of free fall at sea level for the latitude 45° g_n = 9,806 65 m s^{-2} exactly.

Substance concentration (of component B) (c_B; mol m^{-3})

Amount of substance of the component divided by the volume of the system, $c_B = n_B/V$.

Time of centrifugation (t; s)

Time difference from switching on until switching off. The time for deceleration is not included.

Velocity (v; m s^{-1})

Distance traveled divided by time of travel, $v = dl/dt$. Velocity is a vector quantity.

Viscosity (dynamic viscosity) (η; Pa s)

Constant of proportionality for shear stress, τ_{xz} in a fluid moving with a velocity gradient, dv_x/dz, perpendicular to the plane of shear, $\tau_{xz} = \eta \, dv_x/dz$.

Note: This definition applies to laminar flow for which $v_x = 0$.

Volume

The unit litre, L = 0.001 m^3, is customarily used in laboratories instead of m^3 for reporting of analytical results and is recognized for use with SI.