$$E = kT \tag{9.13}$$

where k is Boltzmann's constant and T is absolute temperature (Kelvin).

Thus at $T = 0$ K, molecules possess zero kinetic energy and therefore do not move. E can also be equated with the driving force, F, of particle motion:

$$F = \frac{E}{x} \tag{9.14}$$

At equilibrium:

$$F = F_{\mathrm{d}} \tag{9.15}$$

where F_{d} is the drag force resisting particle motion. According to Stokes' theory, discussed above (Eqn 9.9):

$$F_{\mathrm{d}} = 3\pi d_{\mathrm{h}} \eta v_{\mathrm{st}} \tag{9.16}$$

where d_{h} is the hydrodynamic diameter, v_{st} the Stokes velocity of the particle and η the fluid viscosity, i.e.:

$$E = F\bar{x} = 3\pi d_{\mathrm{h}} \eta v_{\mathrm{st}} \tag{9.17}$$

but

$$\bar{x}^2 = Dt \tag{9.18}$$

and

$$v_{\mathrm{st}} = \bar{x}/t \tag{9.19}$$

substituting,

$$E = 3\pi d_{\mathrm{h}} \eta D \tag{9.20}$$

since $E = kt$ (Eqn 9.13)

$$D = \frac{kT \times 10^{7}}{3\pi\eta d_{h}} \tag{9.21}$$

or

$$D = \frac{1.38 \times 10^{-12} T}{3\pi\eta d_{\mathrm{h}}} \mathrm{m^2 s^{-1}} \tag{9.22}$$

Equation 9.22, known as the Stokes–Einstein equation is the basis for calculation of particle diameters using PCS. This calculation assumes that particles are spherical, and a very low particle concentration is required. The technique determines the hydrodynamic diameter. As colloidal particles in a liquid dispersion have an adsorbed layer of ions/molecules from the dispersion medium that moves with the particles, hydrodynamic diameter is larger than the physical size of the particle (Merkus, 2009). Most instruments also yield a polydispersity index, determined by cumulant analysis as described in the International Standard on dynamic light scattering. The polydispersity index gives information regarding the width of the size distribution, with values ranging between 0 and 1.

Alternative techniques

The instruments vary according to their ability to characterize different particle size ranges, produce complete size distributions, measure dispersions of both solid and liquid particles, and determine molecular weights, diffusion coeff cients, zeta potential or electrophoretic mobility.

Automatic methods

Most of the instruments based on laser light scattering produce a full particle size analysis automatically, with data presented in graphical and tabular forms.

Selection of a particle size analysis method

The selection of a particle size analysis method may be constrained by the instruments available in a laboratory, but wherever possible, the limitations on the choice of method should be governed by the properties of the sample being investigated and the