Aerosol Concentrations and Atmospheric Residence Times

Aerosol concentrations are reported as a number density (# particles/m^3) or a mass density (μg/m^3).

Typical values range from 10 – 500 μg/m^3, ranging from rural temperate climates to coastal areas or arid interior climates.

Urban areas → 200 μg/m^3

Rural forested areas → 10- 50 μg/m^3

Open ocean → 10- 150 μg/m^3

Settling velocity (due to gravity) is governed by;

$$v_t = \frac{(\rho_P - \rho_{air}) C\, g\, d_P^{\,2}}{18\,\eta}$$

where;

ρ_P is density of the aerosol particle (in g/m^3)
ρ_{air} is density of the surrounding air (1.2 x 10^3 g/m^3; at P=1.0 atm & T = 298K)
C is a correction term which depends on the particle diameter (from Table 6.4)
g is 9.81 m/s^2
d_P is the particle diameter (in m)
η is the viscosity of surrounding air (1.9 x 10^{-2} g/m s; at P=1.0 atm & T = 298K)

Co-agulation rate is governed by;

$$\text{rate of change in the number of aerosol particles(N)} = \frac{-dN}{dt} = 4\,\pi\, D\, C\, d_P\, N^2$$

where;

N is number density of the aerosol particles (in particles/m^3)
D is the diffusion co-efficent of the aerosol particle
C is a correction term which depends on the particle diameter (from Table 6.4)
d_P is the particle diameter (in m)

Since D, C and d_P are constants, this can be re-written as $\frac{-dN}{dt} = k_2\, N^2$ where;
k_2 is analogous to a second order rate constant given by $k_2 = 4\pi\, D\, C\, d_P$

1. Compare the settling velocity of 10 μm diameter water droplets to that of carbon soot particles (density = 2.5×10^6 g/m^3).

[*Answer; the soot particles will settle 2.5 times faster than water droplets of equal size*]

2. How long will it take for a collection of fine aerosol particles ($N = 10^9\ m^{-3}$; $d_P = 0.01$ μm) to drop to $5 \times 10^8\ m^{-3}$ through co-agulation processes.

[*Answer = 6800 s ≈ 2 hr*]