020508 Quiz 6 Nanoparticles

1)(35pts)

a) **Show** that the terminal sedimentation velocity, c_s, is proportional to d_p^2 in the continuum regime **and** to d_p in the free molecular regime.

b) The Langevin equation is used to describe the particle flux, J_x, in terms of the concentration gradient and particle velocity.

Write the 1-d Langevin equation for sedimentation.

c) **Plot** log sedimentation flux versus log particle size for the diffusion and sedimentation limits **indicating** the size for the minimum value **and** the transport regime you used. (**show** the slopes)

d) For a sample with a wide unimodal particle size distribution from 10nm to 10 micron, **sketch** the particle size distribution for a sample collected from a sedimentation layer **and** the particle size distribution remaining in an aerosol or suspension.

2)(20pts)

a) For and aerosol of particles smaller than 1 micron with a broad particle size distribution, **will** a representative sample be obtained by thermophoretic sampling?

b) **Why**?

3)(45pts)

a) **Write** the Smoluchowski equation.

b) **Define** the terms.

c) For particles under going Brownian motion, **give** the collision frequency function in terms of the diffusion coefficient and the particle size.

d) **Give** the function for particles in the continuum range.

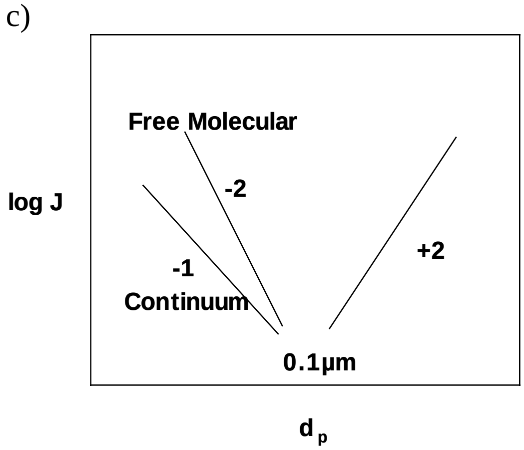
e) **Give** the function for particles in the free molecular range.

Answers: 020508 Quiz 6 Nanoparticles

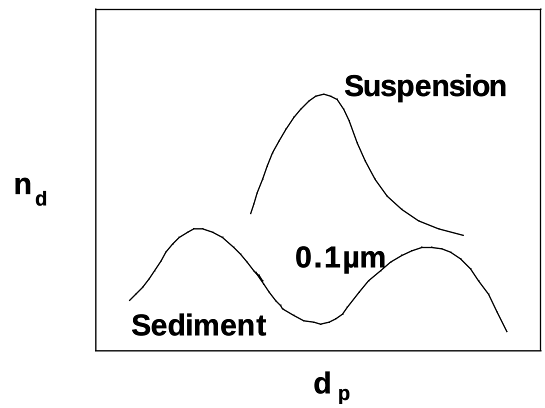
1) a) $F_{gravity} = fc_s \approx d_p^3\ \rho\ g$
so $c_s \approx d_p^3/f$
For the free molecular regime $f \approx d_p^2$ and for the continuum regime $f \approx d_p$ following Stokes law.
Then for the continuum regime $c_s \approx d_p^2$, and for the free molecular regime $c_s \approx d_p$

b) $J_z = -D\frac{\partial n}{\partial z} - c_s n$

c)



d)



2) a) Yes
b) The thermophoretic deposition (velocity) is not particle size dependent in the free molecular range, $c_T = (-3\nu\ \ T)/(4T(1+\pi\alpha/8))$.

3) a) $\frac{dn_k}{dt} = \frac{1}{2}\sum_{i+j=k}\beta(v_i,v_j)n_i n_j - n_k\sum_{i=1}^{\infty}\beta(v_i,v_k)n_i$

b) n is the number concentration of particles, t is time, β is the collision frequency function, v is the particle volume.

c) $\beta_{ij}(v_i,v_j) = 4\pi(D_i + D_j)(a_i + a_j)$

d) $\beta_{ij}(v_i,v_j) = \frac{2kT}{3\mu}\left(\frac{1}{v_i^{1/3}} + \frac{1}{v_j^{1/3}}\right)(v_i^{1/3} + v_i^{1/3})$ **Continuu**

e) $\beta_{ij}(v_i,v_j) = \left(\frac{3}{4\pi}\right)\left(\frac{6kT}{\rho_p}\right)^{1/2}\left(\frac{1}{v_i} + \frac{1}{v_j}\right)^{1/2}(v_i^{1/3} + v_i^{1/3})^2$ **Free Molecul**