0200425 Quiz 4 Nanopowders

1) For a droplet at equilibrium with its vapor,

   -what is the pressure difference between the droplet and its vapor if the liquid has a surface tension, σ and the droplet is of size d_p?

   If a droplet of size r is in equilibrium with a supersaturated vapor with saturation ratio S, **-how does** the droplet size, r, change with the addition of n solute molecules with molecular volume v?

2) Consider a bimodal distribution of silica particles, at atmospheric pressure and room temperature. One mode is centered at 0.01 µm and the other at 10µm.

   -Which of the modes falls in the free molecular regime and which corresponds to the continuum range for particle transport? Why?

   -What is the Knudsen number range for these two cases (relative to 1)?

   -Give an expression for Kn in terms of the number of gas molecules, n, the gas molecular diameter, σ, and the particle size, d_p.

   -If the pressure drops to 0.01 Torr, such as by subjecting the system to a roughing pump, will the situation change? Why?

   -If the temperature is raised to 1700°C, such as in pyrolytic synthesis, will the situation change? Why?

   -What parameter and what equation do you need to describe the flux of these particles if they are subjected to a concentration gradient?

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1) $D_p = 4\sigma/d_p$

$$\ln(S) = \frac{4\sigma v}{d_p RT} - \frac{6nv}{\pi d_p^3}$$

2) The small mode falls in the free molecular range since l_g is about 0.1µm. The large mode is in the continuum range. Kn for the small particle is >1 and Kn for the large particles is <1.

$Kn = \frac{\sqrt{2}}{\pi n\sigma^2 d_p}$, and n = PV/kT for an ideal gas.

For P=>0.01 Torr, n is reduced by a factor of 0.01/760 = 1.3 x 10^{-5}. l_g goes to about 7.8 mm, so both particles are in the free molecular range.

For T => 1700°C n is reduced by a factor of 273/1973 = 0.14 so l_g goes to 0.7µm and the large particles are still in the continuum range since Kn is less than 1 for the large particles.

The particles are subject to Brownian diffusion and the diffusion coefficient is needed to describe the flux, D. For the flux due to a concentration gradient, dn/dx, Fick's first law is needed,

$$J_x = -D\frac{dn}{dx}$$