ATMO/CHEE 469b/569b
Mid-Term 1
February 15, 2006. Up to 50 min. allowed.

Instructions: *All students* – answer question (1) and choose two others from questions (2), (3) and (4), i.e., attempt three questions. If you attempt four questions, only the first three will be graded.
Graduate students – also answer question (5). Undergraduates may attempt this question for up to 10% extra credit.

1.
(a) In words, what does the Reynolds number physically represent? Include a quantitative threshold for an aerosol particle in air.
(b) What is the Knudsen number? Use words, or an equation, but explain the physical significance.
(c) Give a brief description of what we mean by the "Stokes region."
(d) What is a Pitot tube used for?
(e) Physically, why do we sometimes need to include a "slip correction factor" in our calculations?
(f) Sketch a typical aerosol size distribution. Include a numerical scale on the *x*-axis and name three important modes.
(g) Name four of the most common chemical components of the atmospheric aerosol.
(h) Briefly describe the strengths/weaknesses of two commonly used aerosol size distribution functions.
(i) In a few words, why do particles adhere so strongly to surfaces, and why are they so difficult to detach?
(j) What is meant by the term "aerodynamic equivalent sphere"?

(20)

2. The count median diameter of a lognormal size distribution is 2.0 μm and the geometric standard is 2.2. The mass concentration is 1 mg m^{-3}. Calculate the number concentration (ρ_p = 2500 kg m^{-3}).

(10)

3. A rule of thumb states that a 10-μm diameter quartz particle (ρ_p = 2600 kg m^{-3}) settles in air at 1 ft min^{-1} (0.5 cm s^{-1}). Calculate the true settling velocity.

(10)

4. Beginning with Newton's Law (F=ma), derive an expression for the terminal velocity of a particle settling in air.

(10)

Graduate students

5. In the Figure below, label the appropriate arrows as follows:
   count mean diameter
   count median diameter
   count mode
   diameter of average mass
   mass median diameter

(10)

Some Useful Information

$$d_{\bar{m}} = CMD \exp(1.5 \ln^2 \sigma_g)$$

$$F_D = 3\pi\eta V d_p$$

$$V_{TS} = \frac{\rho_p d_p{}^2 g}{18\eta}$$

$$\tau = \frac{m_p C_c}{3\pi\eta d_p}$$

$$\eta = 1.81\times10^{-5}\, kg\, m^{-1} s^{-1}$$

$$g = 9.81\, m\, s^{-2}$$