ATMO/CHEE 469b/569b
Mid-Term 3
May 10, 2006. Up to 2 h allowed.

Instructions: *All students:* Answer question (1).
Choose two others from questions (2), (3) and (4). Only the first two will be graded, if you attempt all three.
Graduate students: Also answer question (5). Undergraduates may attempt this question for up to 10% extra credit.

1.
(a) Name four mechanisms by which particles may be deposited onto filters.
(b) Sketch a typical total-filter collection efficiency curve (efficiency vs. d_p), including approximate numerical scales.
(c) Distinguish between the "inhalable fraction" and the "respirable fraction" of atmospheric aerosols.
(d) List the four major contributing factors to visual extinction.
(e) Name two types of aerosol generator that are commonly used to produce quasi-monodisperse aerosol populations.
(f) Briefly describe an instrument that one might use deliver a controlled source of dust in the laboratory.
(g) Why are the stars invisible during the day?
(h) Why does the sky appear darker blue when looking overhead than when looking towards the horizon?
(i) What is meant by the term "isokinetic sampling"?
(j) How might the orientation of a simple filter disk bias an atmospheric aerosol sample?

(20)

2. You decide to sample 5 μm diameter fog droplets at a rate of 40 L min^{-1} using a probe mounted on a car traveling at 65 mph.
(a) Calculate what diameter probe should be used for isokinetic sampling.
(b) Calculate the maximum sampling error if the speedometer is inaccurate and the true vehicle speed is 75 mph. Assume perfect probe alignment and ignore slip correction.

(10)

3. The air contains ammonium sulfate particles at a concentration of 10 μg m^{-3} (mass scattering coefficient = 6 m^2 g^{-1}); soot at a concentration of 5 μg m^{-3} (mass scattering coefficient = 4 m^2 g^{-1}; mass *absorption* coefficient = 2 m^2 g^{-1}) and NO_2 at a concentration of 0.1 ppm (absorption coefficient = 3×10^{-5} m^{-1} ppm^{-1}). The Rayleigh extinction is 1.0×10^{-5} m^{-1}. Calculate the visual range.

(10)

4. Calculate the face velocity for a filter that is to have a particle diameter of minimum efficiency of 0.5 μm. The filter fiber diameter is 10 μm, and its solidity is 1%. (T = 25 °C.)

(10)

Graduate students

5. Show mathematically why the sky is blue. Use estimates of any parameters you might need in order to quantify your answer. Explain why sunsets are red.

(10)

$$L_v = \frac{3.91}{\sigma_e}$$

$$d_{particle} = d_{droplet}(F_v)^{0.33}$$

$$\frac{C}{C_0} = 1 + \left(\frac{U_0}{U} - 1\right)\left(1 - \frac{1}{1 + (2 + 0.62U/U_0)Stk}\right)$$

$$\tau = \frac{\rho_p d_p^2 C_c}{18\eta}$$

$$Stk = \frac{\tau u_0}{d_{probe}}$$

$$\hat{d}_p = 0.885\left[\left(\frac{Ku}{1-\alpha}\right)\left(\frac{\sqrt{\lambda}kT}{\eta}\right)\left(\frac{d_f^2}{u_0}\right)\right]^{2/9}$$

$$Ku = -\frac{\ln\alpha}{2} - \frac{3}{4} + \alpha - \frac{\alpha^2}{4}$$

$$I(\theta) = \frac{I_0\pi^4 d^6}{8R^2\lambda^4}\left(\frac{m^2-1}{m^2+2}\right)\left(1+\cos^2\theta\right) \text{ for d} \le 0.05\mu\text{m}$$

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

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

$$k = 1.38\times10^{-23}\, kg\ m^2\ s^{-2}\ K^{-1}$$

$$\gamma = 1.81\times10^{-5}\, Pa\cdot s$$

$$\lambda = 0.066\mu m$$

$$1\,\text{mile h}^{-1} = 0.45\,\text{m s}^{-1}$$