ATMO/CHEE 469b/569b
Mid-Term 2
March 31, 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) How would you use a diffusion battery to determine the particle diameter of a monodisperse aerosol?
(b) Briefly describe the physical mechanism accounting for thermophoresis. Does a hot object attract or repel particles?
(c) What is the dominant "force" acting on small (< 0.1 μm) atmospheric aerosols?
(d) Describe Stefan flow?
(e) What effect does the process of coagulation have on aerosol particle size distribution over time?
(f) How can one minimize the rate of coagulation in order to "preserve" an aerosol sample?
(g) Describe the Kelvin effect.
(h) Sketch a Kohler curve and thereby *briefly* explain the existence of clouds?
(i) Define what is meant by the term "electrical mobility"
(j) What factors govern the charge limit of (i) solid and (ii) liquid particles?

(20)

2. Aerosol laden air at 298 °K is sampled through a 1-m long × 0.5 cm diameter tube at a rate of 0.25 L/min. Calculate the percentage of 0.01 μm D_p particles that are lost to the tube walls by diffusion. Assume a slip correction factor of unity and a sticking coefficient of unity.

(10)

3. The atmospheric lifetime of accumulation mode aerosols (D_p = 0.1 μm) is approximately 10 days. Calculate the coagulation-limited maximum number concentration. Assume the coagulation coefficient = 8×10^{-16} m^3/s. For comparison, the average number in urban atmospheres is approximately 10^3 cm^{-3}.

(10)

4. What voltage must be applied to a Millikan oil drop apparatus in order to suspend a singly negatively charged droplet of 0.1 μm diameter? The plates are 5 mm apart and oil has a density of 800 kg/m^3.

(10)

Graduate students

What saturation ratio is required to keep a 0.4 μm diameter droplet of pure water from evaporating at a temperature of 298 °K? Calculate the saturation ratio if the droplet had nucleated on 4×10^{-16} g NaCl.

(10)

Some Useful Information

$$\frac{p_d}{p_s} = \left(1 + \frac{6imM_{solvent}}{M_{salt}\rho_{solvent}\pi d_p^3}\right)^{-1} \exp\left(\frac{4\gamma M_{solvent}}{\rho_{solvent}RTd_p}\right)$$

$$neE = \frac{\rho_p \pi d_p^3 g}{6}$$

$$\mu = \frac{DL}{Q}$$

$$P = \frac{n_{out}}{n_{in}} = 1 - 5.50\mu^{0.67} + 3.77\mu$$

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

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

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

$$\frac{1}{N(t)} - \frac{1}{N_0} = K_0 t$$

$$D = \frac{kTC_c}{3\pi\eta d_p} m^2 s^{-1}$$

$$K_0 = 4\pi D d_p$$

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

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

$$e = 1.60\times10^{-19}\, C$$

$$k = 1.38\times10^{-23}\, JK^{-1}$$

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

$$H = 1$$

$$O = 16$$

$$Na = 23$$

$$Cl = 35.5$$