

Supplemental Homework on Particle Statistics and Size

1. Show that for a constant mass of particles, decreasing the particle size by a factor of 10 increases the surface area by a factor of 10.
2. How many 1 μm diameter particles are required per cubic centimeter of aerosol for the mass concentration to be 10 mg/m^3 ? What is the number concentration in millions of particles per cubic foot?

Ans. 19,098/ cm^3 , 541 mppcf.

3. In smoking one nonfilter cigarette, a smoker inhales 350 ml of aerosol containing 20 mg of tobacco smoke particles. If these particles are unit-density spheres of 0.4 μm diameter, how many particles does the smoker inhale from one cigarette? What is the mass concentration of the smoke? Make a ratio comparison of this smoke concentration to the U.S. National Ambient Air Quality Standard (annual average) of 75 $\mu\text{g}/\text{m}^3$.

Ans. 6.0×10^{11} , 57 g/m^3 , 762,000.

4. Air in a workroom has a particle concentration of 1 mg/m^3 , is at 20 $^\circ\text{C}$ and 1 atmosphere pressure. What fraction of the total mass of workroom air, comprising both air and particles, is made up of particles?

Ans. 8.7×10^{-7}

5. Using the scanning electron microscope, you measure the size distribution for some metal fume. Your findings are given in the table below.

Diameter								
Range, μm	0.05-0.1	0.1-0.2	0.2-0.4	0.4-0.8	0.8-1.6	1.6-3.2	3.2-6.4	>6.4
Count	24	65	78	40	16	3	1	0

Do the following. All cumulative plots should be on the same piece of log-probability paper for easy comparison.

- a) Plot a frequency distribution by count for these data
- b) Plot a cumulative distribution by count for these data on log-probability paper.
- c) Determine the count median diameter for these particles.

- d) As best you can, pass a straight line through the data on the log-probability plot to yield a log-normal approximation to the data.
- e) Determine the geometric standard deviation for this log-normal approximation.
- f) Using the Hatch-Choate equation, estimate the mass median diameter for this size distribution.
- g) Plot a log-normal approximation to the cumulative distribution by *mass* using the results from (f) for mass median diameter and results from (e) for geometric standard deviation.
- h) Using the $n_i d_i^3$ method, convert the count distribution to a mass distribution, then plot this cumulative distribution by mass on log-probability paper. Note that this is the true cumulative distribution by mass because it makes no assumptions about log-normality.

Based on your results, what is your opinion on the following points:

- i) From the cumulative distribution by count from (b) and (d) above, do the particles in this aerosol look log-normally distributed?
- j) Do the cumulative distribution by mass calculated from (g) using the log-normal approximation to the data agree with the cumulative distribution by mass calculated from (h) without assuming log-normality? What does the level of agreement say about the closeness with which the size distribution approaches log-normality?