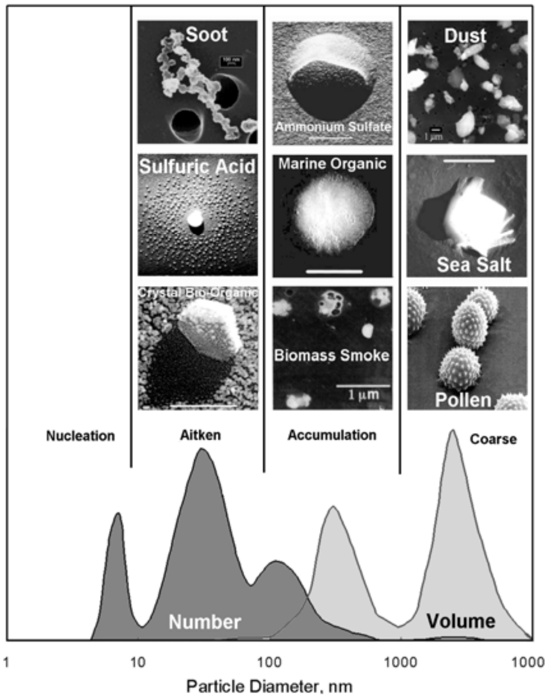

Aerosols are a complex ingredient to the atmosphere, which can result in both environmental and human health problems when their concentrations are too high. Smog and soot from burning fossil fuels or other organic materials can cause breathing difficulties, and perhaps even some forms of cancer.

The figure shows some common types of aerosol particles and their sizes. Most appear to be small spherical particles when seen under the microscope.

The formula for the volume of a sphere is given by $V = 4/3 \pi R^3$. Also, 1 micron (μm)= 0.0001 centimeters, and 1 nanometer (nm) = 0.001 microns.

Problem 1 – A cubic meter container contains aerosols composed of soot produced from the combustion of diesel fuel. Each spherical aerosol particle has a density of 2 grams/cm^3. If the soot particle has a diameter of 20 nanometers, how much mass is in a single soot particle expressed in A) grams? B) micrograms?

Problem 2 – Scientists like to use two measurement units to indicate the density of aerosols in a sample of air: Particles/meter^3 or micrograms/meter^3 (μg/m^3). The average aerosol density for Los Angeles, California between October 2002 and September 2003 was 40 μg/m^3. 50% of these aerosols by mass were particulates with diameters of about 5 microns, while the remaining aerosols were mostly 500 nanometers in size. What was the density of the aerosols in particles/m^3 in each case, if the aerosols were small solid spheres with a density of 3.0 gm/cm^3?

Problem 1 – A cubic meter container contains aerosols composed of soot produced from the combustion of diesel fuel. Each spherical aerosol particle has a density of 2 grams/cm3. If the soot particle has a diameter of 20 nanometers, how much mass is in a single soot particle expressed in A) grams? B) micrograms?

Answer: First convert the particle diameter to centimeters:

$$D = 20 \text{ nanometers} \times \frac{1.0\times10^{-9} \text{ meters}}{1 \text{ nanometer}} \times \frac{100 \text{ cm}}{1 \text{ meter}} = 2.0\times10^{-6} \text{ cm.}$$

$V = 4/3\ \pi\ R^3$, and $R = D/2$, so $V = 1.333 \times 3.141 \times (1.0\times10^{-6} \text{ cm})^3 = 4.2 \times 10^{-18} \text{ cm}^3$.

Mass = density x volume, so

A) Mass = $2.0 \text{ gm/cm}^3 \times 4.2 \times 10^{-18} \text{ cm}^3 = 8.4\times10^{-18}$ grams.
B) Mass = 8.4×10^{-18} grams x (1 microgram/ 10^{-6} grams) = **8.4×10^{-12} micrograms**.

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Answer: Aerosol masses:

5 micron case: $R = 2.5\times10^{-4}$ cm then $V = 4/3\ \pi\ (2.5\times10^{-4} \text{cm})^3 = 6.5\times10^{-11} \text{ cm}^3$.
Mass = $3.0 \text{ gm/cm}^3 \times 6.5\times10^{-11} \text{ cm}^3 = 2.0\times10^{-10}$ gm.

500 nanometer case: $R = 5.0\times10^{-5}$ cm. $V = 4/3\ \pi\ (5.0\times10^{-5} \text{ cm})^3 = 5.2\times10^{-13} \text{ cm}^3$.
Mass = $3.0 \text{ gm/cm}^3 \times 5.2\times10^{-13} \text{ cm}^3 = 1.6\times10^{-12}$ gm.

Since 50% of the aerosols were in each category and the total density was 40 μg/m^3,

5-micron case: $$\text{number} = 20\ \mu\text{g/m}^3 \times \frac{1 \text{ gm}}{10^6\ \mu\text{g}} \times \frac{1 \text{ particle}}{2.0\times10^{-10} \text{ gm}} = \mathbf{10^5 \text{ particles/m}^3}$$

500 nm case: $$\text{number} = 20\ \mu\text{g/m}^3 \times \frac{1 \text{ gm}}{10^6\ \mu\text{g}} \times \frac{1 \text{ particle}}{1.6\times10^{-12} \text{ gm}} = \mathbf{1.2\times10^6 \text{ particles/m}^3}$$

So although there were an equal amount of particles by their total mass, the small particles were 120 times more numerous as individual particles in the air samples.