Because of their impacts to health, the US Environmental Protection Agency monitors the level of aerosols in the atmosphere (troposphere) for two categories: Large aerosols (PM$_{10}$) with diameters near 10 microns, and small aerosols (PM$_{2.5}$) with diameters near 2.5 microns ($\mu$m). The Air Quality Index (AQI) relates the density of each aerosol type (measured in micrograms per cubic meter or $\mu$g/m$^3$) to health risk as shown in the table above.

**Problem 1** - Suppose the two types of aerosol particles have a density of 2000 kg/m$^3$. Assuming that each particle is a perfect sphere, what are the average masses of each type of aerosol particle in kilograms?

**Problem 2** – Based on your estimate of the aerosol particle masses in Problem 1, how many aerosol particles of each type would be present in a 1 cubic meter volume of air of the AQI was 150?
**Problem 1** - Suppose the two types of aerosol particles have a density of 2000 kg/m$^3$. Assuming that each particle is a perfect sphere, what are the average masses of each type of aerosol particle in kilograms?

Answer: Volume = $\frac{4}{3} \pi R^3$,

PM$_{2.5}$ aerosols: For $R = 1.3$ microns, $R = 1.3 \times 10^{-6}$ meters so

$V = 1.333 \times 3.141 \times (1.3 \times 10^{-6})^3$

$= 9.2 \times 10^{-18}$ m$^3$.

Mass = density x volume, so

$M = 2000 \times 9.2 \times 10^{-18}$

$= 1.8 \times 10^{-14}$ kilograms.

PM$_{10}$ aerosols: $R = 5$ microns so

$V = 1.333 \times 3.141 \times (5.0 \times 10^{-6})^3$

$= 5.2 \times 10^{-16}$ m$^3$, then

$Mass = 2000 \times 5.2 \times 10^{-16}$

$= 1.0 \times 10^{-12}$ kilograms.

**Problem 2** – Based on your estimate of the aerosol particle masses in Problem 1, how many aerosol particles of each type would be present in a 1 cubic meter volume of air of the AQI was 150?

Answer: The table indicates that for an AQI of 150, the density of the PM$_{10}$ particles would be 254 μg/m$^3$. Since the mass of such an aerosol particle is about $1.0 \times 10^{-12}$ kilograms, we have

$N = 2.54 \times 10^{-6} \mu g/m^3 \times (1 kg/1000 gm) \times (1 particle/1.0 \times 10^{-12} kg)$

$= 2500$ particles/meter$^3$.

The table indicates that for an AQI of 150, the density of the PM$_{2.5}$ particles would be 65.4 μg/m$^3$. For PM$_{2.5}$ aerosols the density is 65.4 mg/m$^3$. The average mass is $1.8 \times 10^{-14}$ kg, so

$N = 65.4 \times 10^{-6} \mu g/m^3 \times (1 kg/1000 gm) \times (1 particle/1.8 \times 10^{-14} kg)$

$= 3.6 \times 10^6$ particles/meter$^3$. 