In 2012, the dry mixing ratio volume of sulfur hexafluoride (SF$_6$) in the atmosphere was about 7.5 parts per trillion by volume (“pptv” or “ppt”). Convert this value into the mass density of SF$_6$ at sea level ($P = 1013$ mb, 298 K) in units of micrograms of SF$_6$ per cubic meter of air (“µg m$^{-3}$”).

**Source of information:**

$\text{MW(SF}_6\text{)} = 146$ g mol$^{-1}$

**Methodology:**

Convert mixing ratio ($X$) into concentration, then into moles. Use molecular mass to calculate mass density (e.g., grams SF$_6$ per volume of air).

**Equation:**

$$\rho_{(\text{SF}_6)} = \text{grams SF}_6\text{ per m}^3\text{ of air} = X(\text{SF}_6) \times [M] \times \text{MW(SF}_6\text{)} / 6.02 \times 10^{23}$$

$$= (7.5 \times 10^{-12}) \times [(7.25 \times 10^{18} \text{ molec cm}^{-3}) \times P(\text{mbar})/T(K)]$$

$$\times (10^6 \text{ cm}^3 \text{ m}^{-3}) \times (146 \text{ g mol}^{-1}) \times (10^6 \text{ µg g}^{-1})/ (6.02 \times 10^{23} \text{ molec mol}^{-1})$$

$$= 1.320 \times 10^{-2} \text{ µg m}^{-3} \times P(\text{mbar})/T(K)$$

**Result:** For 1013 mbar and 298 K,

$$\rho_{(\text{SF}_6)} = 1.320 \times 10^{-2} \text{ µg m}^{-3} \times 1013/298$$

$$= 0.05 \text{ µg m}^{-3}$$

**Reflection:** Lots of conversions, but relatively straightforward. This is an interesting result. We will see later that typical particulate masses in clean rural areas are around 5-10 µg m$^{-3}$. So for source molecules that have molecular weights of 100 g mol$^{-1}$ (typical of condensable compounds), we would need about 100-200 times the mixing ratio of SF$_6$, or around a part per billion in mixing ratio, in order to produce this amount of condensed material. We’ll also see later that when organic molecules oxidize, they don’t yield 100% condensable materials – more like 10%, so we really need around 10 parts per billion of a pollutant in the air in order to see the levels of particulate matter that are in relatively clean air.