Handout 8: Sulfuric Acid in the Venusian Atmosphere

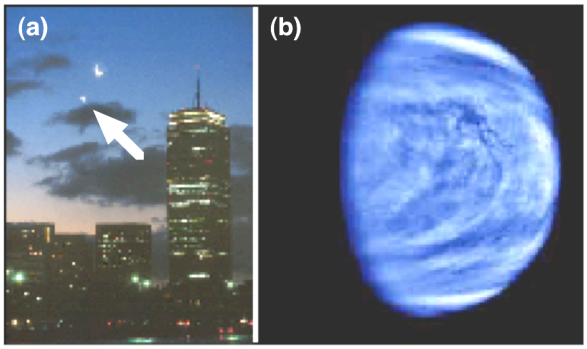

Figure 1: The planet Venus. (a) Even without magnification, Venus is often visible as here above the Boston skyline. (b) Venus from space.

The planet Venus (see Figure 1[1]) is surrounded by a dense atmosphere that is composed of carbon dioxide (96%) with traces of nitrogen (3%) and water vapor (0.003%)[2]. As is shown in Figure 1(b), the atmosphere of Venus has clouds that appear (from a distance) to resemble clouds on the Earth. The clouds of Venus are made up of droplets of concentrated sulfuric acid (H_2SO_4). The cloud layer begins about 30km above the surface of Venus, and ends at about 60km above the surface. Below the cloud layer (0-30km above the surface of Venus) the atmosphere includes a "haze" of sulfuric acid droplets.

(a) Figure 2[3] shows a cross-sectional view of part of the Venusian atmosphere. The piece of the Venusian atmosphere represented by the large shaded "ring" in Figure 2 is at a height of x km above the surface of the planet, and has a thickness of dx kilometers. In a sentence or two describe the appearance of this "slice" of the Venusian atmosphere and find a formula for its volume. The radius of the planet Venus is approximately 6052 km.)

[1] Image source: (a) http://www.mos.org/ (b) http://www.nasa.gov/

[2] Source: http://nssdc.gsfc.nasa.gov/planetary/factsheet/venusfact.html

[3] This diagram was made with an image from: http://www.nasa.gov/

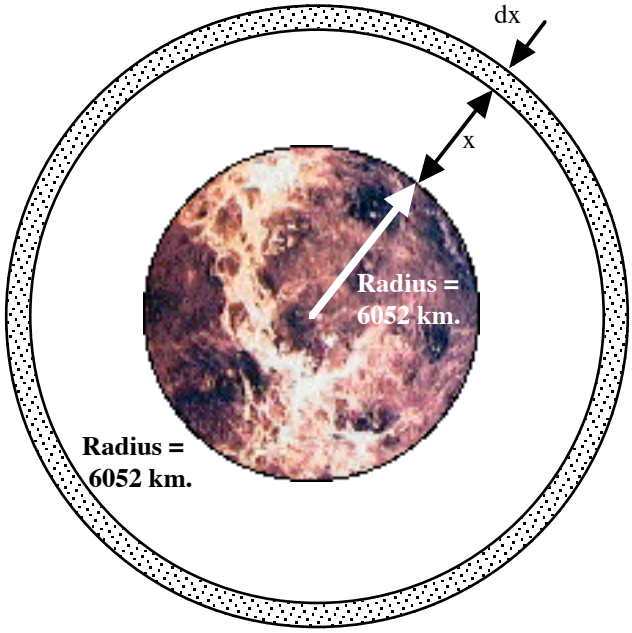

Figure 2: Cross-sectional view of a "slice" of the Venusian atmosphere. The slice shown is at a height of "x" km above the surface of the planet, and has a thickness of "dx."

(b) Figure 3[4] shows the concentration of sulfuric acid in the Venusian atmosphere as a function of altitude for the cloud layer (30-60 km above the surface). The concentration of sulfuric acid in the "haze layer" (0-30 km above the surface) is about 35.68 metric tons per cubic kilometer. (The units of the concentration are always metric tons per cubic kilometer in this assignment.) Set up two integrals, one that gives the amount of sulfuric acid (in units of metric tons) in the haze layer and one that gives the amount of sulfuric acid (in units of metric tons) in the cloud layer of Venus. The curve in Figure 3 is approximated by the equation:

$$y = 0.001 \cdot x^4 - 0.26 \cdot x^3 + 16.74 \cdot x^2 - 472 \cdot x + 4886.48 .$$

[4] The data used to construct Figure 10 is taken from: M.A. Kolodner and P.G. Steffes. (1998) "The microwave absorption and abundance of sulfuric acid vapor in the Venus atmosphere based on new laboratory measurements." *Icarus*, **132**(3): 151-169.

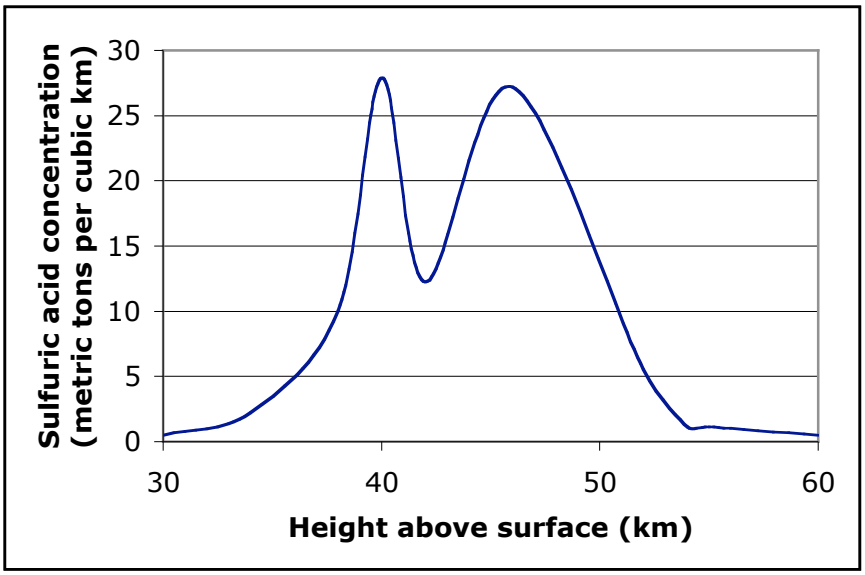

Figure 3: Concentration of sulfuric acid in Venus cloud layer.

(c) Calculate the numerical value of the integral that you have set up for the amount of sulfuric acid in the haze layer. Describe (and perform) a simple calculation - based on geometry rather than calculus – that will enable you to check your answer to this problem. In a sentence or two, explain why you could not use a similar, simple calculation to check your answer if you had been asked to work out how much sulfuric acid was in the cloud layer of Venus.