ASTR/GEOL-2040-001: Search for Life in the Universe
Homework #5 Due: Monday October 30, 2017 model solutions

Use the plot on the backside for your answer to question 2. Write all other answers on *separate* sheets of paper and staple them together.

The Labeled Release (LR) experiment on Viking 1 and 2 was the only one that resulted in a positive response. The latest account of those findings has been recently been published by

> Levin, G. V., & Straat, P. A.: 2016, "The Case for Extant Life on Mars and Its Possible Detection by the Viking Labeled Release Experiment," *Astrobiol.* **16**, 798–810

see `http://lcd-www.colorado.edu/~axbr9098/teach/ASTR_2040/material/` for a local copy of `Levin+Straat16.pdf` (and other potentially interesting papers). *Work with the 2016 paper* (i.e., read mainly what you need) to answer the following questions.

(i) What kind of compounds did the nutrient solution consist of?
The nutrient solution consisted of Miller-Urey compounds.
[Also correct would be: sodium formate, sodium lactate, glycine, alanine, and calcium glycolate.]

(ii) Using their Figure 2, what are the approximate count rates per minute of any released ^{14}C-based gases for Viking Lander 1 after about 5 hours and after about 24 hours?
About 3000 and 7000 counts/minute, respectively.

(iii) Using their Figure 3, what was the approximate count rate for their California "Aiken" soil sample under terrestrial conditions after about 5 hours and under Martian conditions after about 24 hours?
About 70,000 counts/minute under terrestrial conditions after about 5 hours and between 2000 and 3000 counts/minute Martian conditions after about 24 hours.

(iv) Later in the mission, a modified control was introduced for Viking Lander 2. Why did they do this and what was the result? Why was this modification thought to be particularly suitable for Mars compared to Earth?
There was concern that at 160°C the soil might get chemically altered. This could be alleviated by heating to only 50°C. This was deemed cold enough so that any life that would have adapted to the cold Martian conditions (which might be expected to be non-thermophilic) would not survive. Indeed, very low count rates (between 700 and 1000 counts/minute) were detected after several days.

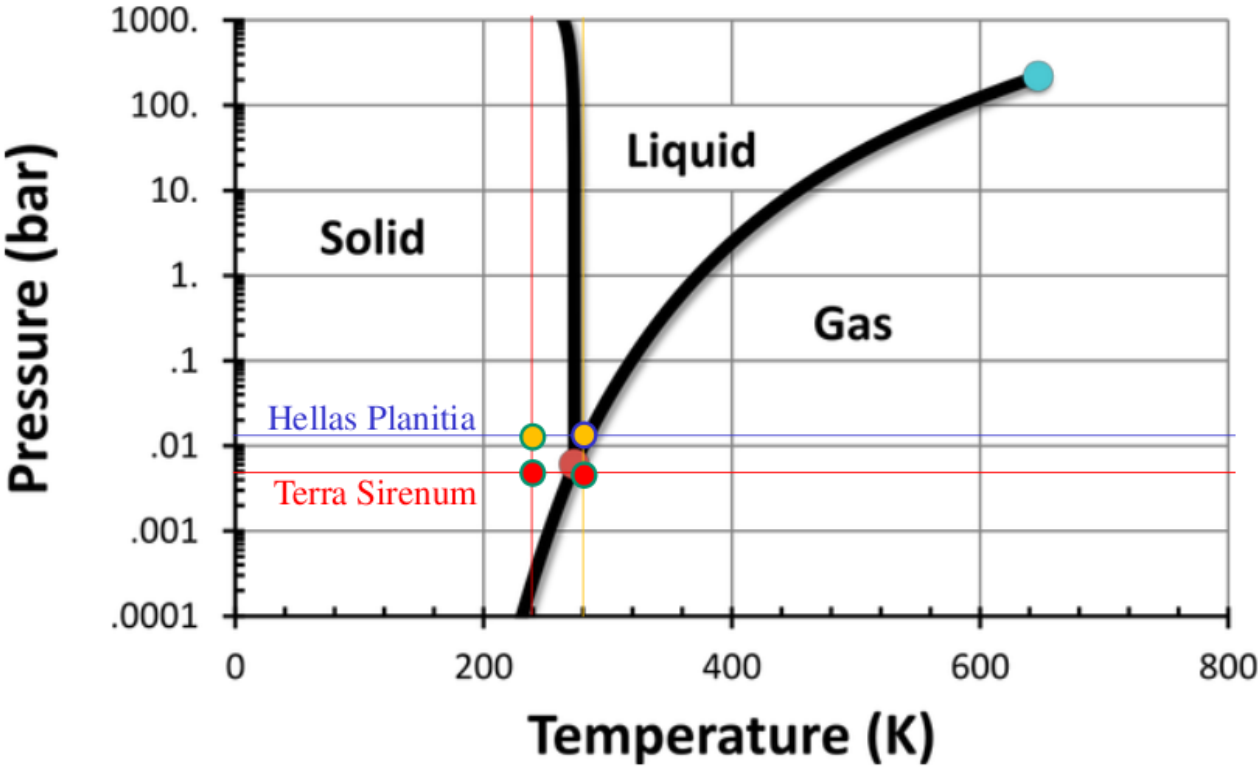
(v) On Viking Lander 2, during cycle 5, an improvised experiment was conducted on a soil sample that had previously being tested. For how long and at what temperature had this sample been stored and what was the result?
It was stored for 84 sols at 10°C. The resulting count rate was around or below a few hundred.

(vi) Why is a biological explanation difficult to accept? [Hint: which other Viking experiment yielded results incompatible with life?]
The GCMS reported no organic molecules. The presence of life should have manifested itself through the presence of organic molecules.

(vii) Which nonbiological explanations have been put forward? What are the problems with these explanations?
Oxidation by perchlorates, but this would not explain the absence of a detection for the controls.

2. We have known for some time that Mars' surface pressure is generally too low to support liquid water, but this is only true most of the time. Using the phase diagram of water (next page), answer the following questions to see how close Mars is to supporting liquid water on its surface.

(i) The air pressure at Terra Sirenum (see Google Mars for details!) is typically 5 mbar and has a temperature of about 240 K. Mark these surface conditions on the plot with a point. What phase would you expect water on Mars to be from this information?
The point is marked in red. It is in the solid phase.



(ii) Assuming that the air pressure could be held constant, would it be possible to raise Mars' surface temperature to the point where liquid water could exist?
No; water would turn to gas (i.e., sublimate) above about 270 K.

(iii) At Hellas Planitia, the floor of the Hellas Impact Basin, surface pressures soar to 11 mbar. Assuming the same 240 K surface temperature, please mark the surface conditions of Hellas Planitia on the phase diagram. What phase of water would you expect to exist here?
The point is marked in orange. Water would still be solid.

(iv) Suppose we recalculate our values for Mars' southern summer – when the planet is physically closer to the Sun. Let's suppose the increased sunlight raises the temperature by 17%, and let's ignore changes in pressure, draw your two temperatures using this larger temperature. Do either of your previous locations potentially allow for liquid water?
17% more temperature would mean $240\,\mathrm{K} + 41\,\mathrm{K} = 281\,\mathrm{K}$ The point is marked in orange. Water would now be liquid.