AST 105 HW #8 Solution

Week of October 12th, 2015

Note: All Problems are from *The Cosmic Perspective* (6ed)

**Chapter 10**

**Review Problems**

1. Briefly summarize the atmospheric properties of the five terrestrial worlds. How do they differ in surface temperature, pressure, and compositions?

   - Mercury: Its atmosphere is made of helium, sodium and oxygen. The surface pressure is \(10^{-14}\) bar. The average temperature is 425 °C in the day and -175 °C in the night. There are no winds, since there is too little atmosphere. There are no clouds.
   - Venus: Its atmosphere is made of 96 % carbon dioxide and 3.5 % nitrogen. The surface pressure is 90 bards. The average temperature is 470 °C. There are slow winds and acid rain, no violent storms. There are acid clouds.
   - Earth: Its atmosphere is made of 77% nitrogen, 21% oxygen, 1% argon, and variable amount of water stream. The surface pressure is 1 bar. The average temperature is 15 °C. There are winds, hurricanes, rain and snow. There are water clouds and pollution.
   - Moon: Its atmosphere is made of helium, sodium, and argon. The surface pressure is \(10^{-14}\) bar. The average temperature is 125 °C in the day and -175 °C in the night. There are no winds, since there is too little atmosphere. There are no clouds.
   - Mars: Its atmosphere is made of 95% carbon dioxide, 2.7% nitrogen and 1.6% argon. The surface pressure is 0.007 bar. The average temperature is -50 °C. There are winds, and dust storms. There are water clouds, carbon dioxide clouds and dust.

2. Is there any atmosphere at the orbital altitude of the Space Station above Earth? Explain.

   - There is some atmosphere at the orbital altitude. Atmospheres do not abruptly end: They fade away with altitude. So while the air at the Space Station’s altitude is extremely thin, it is present and causes drag on the Station, which means that the Station must periodically be boosted back up to keep it from falling to Earth.

3. Why does convection occur in the troposphere, leading to active weather, but not in the stratosphere?

   - We get convection in the troposphere because it is heated from below. Convection allows this heat to escape upward when radiation is too inefficient. Radiation is inefficient in the troposphere because of the greenhouse gases, which try to stop the ultraviolet radiation from escaping. However, in the stratosphere the heating occurs everywhere, although it is concentrated near the middle of the layer. With a thinner atmosphere in that layer, there is much less to keep the infrared from escaping outward, so convection is not needed to help the heat escape.

4. What is the difference between weather and climate?
Weather describes the atmospheric conditions at a given time in a given place. This includes air pressure, cloud cover, temperature, winds, and precipitation. Weather changes rapidly, over hours or days. Climate is a long-term average of the weather and changes much more slowly, usually over decades or longer.

15. Describe each process by which atmosphere gain or lose gas. What factors control thermal escape? Which loss processes are permanent?

Atmospheres can gain gases in three ways. The first is outgassing, the emission of gases from the interior of a planet into the atmosphere through volcanic activity. The second process that adds gases to the atmosphere is evaporation or sublimation, the process where the solid or liquid states change to gases. Finally, on planets with thin atmospheres, micrometeorites, high-energy particles, and high-energy photons can strike the planet's surface and vaporize rock.

Planets can lose atmospheric gases four ways. The first is thermal escape: Particles gain enough energy near the top of the atmosphere to escape the planet's gravity. Second, particles can condense back into a liquid or solid state onto the surface, leaving the atmosphere. Third, atmospheric gases can have chemical reactions with surface materials and leave the atmosphere. Fourth, particles can be stripped away from the planet's upper atmosphere by collisions with solar wind particles. The factors that determine what gases will be lost through thermal escape are the planet's escape speed (a higher escape speed means that molecules need more energy to escape), the temperature (hotter gases have more energy per molecule, so the molecules are more likely to be able to escape), and the mass of the molecule (heavier molecules move more slowly at the same temperature and so don't escape as easily).

18. How do we think that Mars lost atmospheric gas? What basic planetary property (size, distance from the Sun, or rotation rate) would have had to be different for Mars to have retained a thicker atmosphere?

In the early history of the Mars probably it had molten, convecting metals in its core like the Earth. The rotation of the Mars with these convecting metals produces a magnetic field and a protective magnetosphere. But the magnetic field of the Mars is weakened as it is small and cooler planet and core convection is ceased. The atmosphere was then stripped away to space by solar wind particles.

If Mars had been a bigger size, the planet would have retained its magnetic field, and thus have a thicker atmosphere.

19. What do we mean by a runaway greenhouse effect? Explain why this process occurred on Venus but not on Earth?

A runaway greenhouse occurs when a planet gets so hot that it cannot keep liquid water stable on the surface. As the planet heats up, more water is vaporized into the air. A potent greenhouse gas, the water vapor raises the temperature further. This evaporates more water, causing the cycle to continue. This did not occur on Earth, but did happen to Venus, because Earth is farther from the Sun and therefore was not hot enough to start this cycle.

Test Your Understanding

Decide whether the statement makes sense (or is clearly true) or does not make sense (or is clearly false). Explain clearly; not all of these have definitive answers, so your explanation is more important than your chosen answer.
29. Mars once may have been warmer than it is today, but it could never have been warmer than Earth because it is farther from the Sun than Earth is.

=> False. With enough greenhouse gases, or even reflectivity differences, it's possible that Mars could have been warmer than Earth. Temperature depends on more than distance.

32. A planet in another solar system has no life but has an Earth-like atmosphere with plentiful oxygen.

=> This would be very hard to explain, since oxygen is not stable in our atmosphere without continuous resupply by living things.