**Astronomy 3 -Solution Set 6**

1. **The atmosphere of the Earth has loss of most of its hydrogen content through thermal escape. How did it avoid losing its nitrogen and oxygen content?**

   The average thermal speed of the molecules is proportional to the square root of the ratio of temperature and mass of the atoms. Although hydrogen, nitrogen, and oxygen attain the same temperature in the Earth atmosphere, the thermal speed of the latter species are much slower than that of hydrogen. Hydrogen molecules are lost because their thermal speed exceeds that of the escape velocity of the Earth. Nitrogen and Oxygen molecules are retained because their thermal speeds are smaller than the escape speed of the Earth.

2. **The Earth and the moon is at the same distance from the Sun. Why is the Earth able to retain its atmosphere whereas the Moon did not?**

   The moon has a smaller mass and density. Consequently, the escape speed of the Moon is nearly 5 times smaller than that of the Earth. Since they are at the same distance from the Sun, the equilibrium temperature and the average thermal speed on their surface are nearly the same. Under these circumstances, atmospheric molecules escape from the Moon much more easily than from the Earth.

3. **We observe the size of Martian north polar cap of changes periodically over the time scale 2 years. What process causes these changes? What happens to the southern polar cap? How is the planet-wide dust storm related to these changes?**

   The Martian polar cap is mostly composed of frozen carbon dioxide. Since Mars' spin axis is tilted by a comparable amount as the Earth, there are seasons on Mars, similar to that on the Earth. During the winter in the northern hemisphere on Mars, the temperature drops below the frozen point for carbon dioxide. The condensation of dry ice causes the polar cap to expand and the atmospheric pressure to drop. Concurrently, the polar cap decreases and atmospheric pressure increases due to the evaporation of dry ice on the southern hemisphere. These events introduces a gradient in the pressure and air flows from the southern to northern hemisphere. Similar events occur in the reverse direction during the winder of southern hemisphere half an orbital period (1 year) later.

4. **Briefly describe what is the Greenhouse effect. Why is it more severe on Venus than it is on Earth? Describe one supporting evidence that it is on the rise on Earth.**

   The greenhouse effect is the process by which gas (mainly CO2, methane, and water) in an atmosphere makes a planet's surface temperature warmer than it would be in the absence of the atmosphere. Sunlight consists mostly of visible light which passes easily through most atmospheric gas to reach a planet's surface. Some visible light is absorbed and re-emitted in the infrared wavelength. The greenhouse gas absorb and trap some of the infrared photons and become heated. Venus has a massive atmosphere with a high concentration of CO2. The composition of Venus atmosphere make it much more effective in trapping the infrared photons and promote greenhouse effects than the Earth. An evidence which indicates the greenhouse effect is on the rise is the atmospheric content of a major greenhouse gas, CO2 which has been steadily increasing in the past few decades. Examples of a direct impact are associated the phenomenon of global warming, eg the melting of the ice sheets and retreat of the glaciers.

5. **Why do hurricanes always circulate in one direction in the northern hemisphere and in the opposite direction in the southern hemisphere? If each day is shortened to 12 hours, what will happen to the circulation pattern?**

   The first major factor affecting global wind is atmospheric heating. In general, the equatorial regions of a planet receive more hear from the Sun than do polar regions. The excess heat makes the atmosphere expand above the equator so that it rises upward and moves toward the poles. Near the poles, cool air descends and flows toward the equator, leading to circulation cells. The second major factor affecting global wind patterns is a planet's rotation, which can split each circulation cells into several smaller ones through the Coriolis effect. The direction of the deflection is perpendicular to both the spin and

direction of the wind flow. In the northern hemisphere, an equator to pole flow would be deflected to the left whereas an pole-ti equator flow would be deflected to the right. In the southern hemisphere, the direction of the deflection is exactly opposite. When this circulation intensifies into a storm, a hurricane is formed. The spin of the hurricanes preserves the direction of the circulation and that is why they rotate in the opposite sense in the northern and southern hemisphere. A rapidly spinning planet experience a stronger the Coriolis force and the circulation cells become more narrow, confined, and numerous. If the earth is shorten to 12 hours, we would have several more circulation cells than today and the hurricanes may also become more intense.

6. **Cite two pieces of evidences which suggest that Mars once had a much more liquid water on its surface than today. Where did the water go? How is this process linked to the red color of Mars? How did the Earth avoid this loss of water?**

   We see evidence of erosion by rainfall, and perhaps, even lakes and oceans some 3 Gyr ago. We also see Gyr old floodplains. The Mars Pathfinder spacecraft landed at a site that may have witnessed one of the biggest floods in the history of the solar system. On the surface, the pathfinder released a Sojouner rover which carried cameras and instruments to measure the chemical composition of nearby rocks. Rocks of many different types are jumbled together and stacked against each other, as as we find in the aftermath of a flood on earth. Today the surface temperature of Mars is too cold and pressure is too low for liquid water to exist. Much of it may be frozen beneath the surface. The presence of water, once on Mars, indicate that the planet must have had a substantial atmosphere at one point because liquid water can only exist in atmospheres with modest pressure and density. Being a small planet, the interior of Mars has cooled down and there is little mantle motion to generate magnetic fields on it. The atmospheric molecules on Mars are not shields from the energetic particles from the solar wind and ultraviolet radiation. These photons and particles can easily break apart the water molecules. As the lightest element, the hydrogen atoms attain large recoil speed and are knock out of the Martian atmosphere. The remaining oxygen combined together with iron and other elements through an oxidation process. The red color on the surface of Mars is a reflection of this ongoing oxidation process. The Earth has a much larger mass than Mars. It still has a molten interior which can generate magnetic fields. This magnetic field provides a shield for the earth against the energetic particles from the solar wind. Biological activities also lead to the production of ozone which helps to absorb the Sun's ultraviolet radiation. Consequently, the water molecules are rarely broken apart by the solar wind and radiation. In addition, gravity on the surface of the Earth is stronger than that on the surface of Mars. It is also more difficult for the earth atmosphere to be ejected.