The Planets!
Astro 10, spring 2010

Mercury

1. Mercury, like the Moon, has a slow rotation rate (relative to that of the Earth). Explain why.
   Tides (due to Earth in the Moon’s case and due to the Sun in Mercury’s case) have slowed the rotation rate down.

2. Also like the Moon, Mercury has essentially no atmosphere. Why might this be?
   Both are small, so they don’t have strong surface gravity to hold onto an atmosphere. Also, in Mercury’s case, it is hot, which makes it even more difficult for Mercury to hold onto an atmosphere.

3. Both the Moon and Mercury are heavily cratered, but Mercury has a higher surface gravity than the Moon. How does this affect the cratering we see on their surfaces?
   You will notice two effects: the rims of the craters will be higher on the Moon than on Mercury since the Moon has weaker surface gravity. Also, the secondary craters (caused by chunks of rock thrown up by a large impact and falling back down to create small craters around the main crater) are further from the primary crater on the Moon compared with on Mercury. Since the gravity on Mercury is stronger, the secondary chunks of material just don’t travel as far before they fall back down onto the surface to create the secondary craters.

Venus

1. The age of the surface of Venus is estimated to be a uniform 800 million years old. Compare this age to the estimated age of the solar system. What does this suggest about surface processes on Venus?
   The age of the solar system is about 4.6 billion years, so the surface of Venus is only $\sim 17\%$ the age of the solar system. This means that there are processes (in this case, volcanism) that resurfaced Venus 800 million years ago.
2. How does the total amount of CO$_2$ on Venus compare with that on Earth? Why are the two planets atmospheres so different?

Venus’s atmosphere is 96% CO$_2$, compared with less than 1% on Earth. On Earth, the CO$_2$ is trapped in seawater and rain, which is used to form the shells of marine lifeforms, which are eventually turned into rocks (i.e., limestone). This traps the CO$_2$ in rocks, keeping it out of the atmosphere. Venus has no oceans or rain in which to dissolve the CO$_2$ and get it out of the atmosphere.

3. The surface of Venus is very hot due to the greenhouse effect. Draw a diagram to explain how the greenhouse effect works.

The atmosphere allows visible light through, but is opaque to infrared light. So, the light from the Sun (mostly in the visible part of the spectrum) makes it through the atmosphere to the ground and heats the ground. The ground then emits photons as a blackbody, but it’s peak is in the infrared and infrared photons are reflected by the atmosphere back to the ground. So the infrared photons can’t escape, and the ground is heated and can’t cool off. See fig. 6-40 in the textbook for a diagram.

**Mars**

1. What evidence is there that water once flowed on Mars?

   Channels on the surface that look like streambeds on Earth.

2. Olympus Mons is approximately three times higher than Mount Everest. Explain why a planet with a radius $\approx 1/2$ that of the Earth might have such large mountains.

   Two effects contribute: one is that the surface gravity on Mars is less. Second is that Mars has no tectonic plates, so when a hot spot creates a volcano, it stays in the same place and thus can build the volcano up to be much larger than on Earth, where the tectonic plates shift slowly, moving the volcano on the surface.

3. Mars has two small moons, Deimos and Phobos. What is the current theory for their origin?

   Deimos and Phobos look just like asteroids: they are oddly shaped (not spherical) and very small. Therefore, we suspect that they are captured objects, not formed with Mars.
**Jupiter**

1. Jupiter has the fastest rotation rate of any planet in the solar system. Explain how this effects the shape of the planet.
   
   Jupiter is flattened due to the fast rotation so that it is sort of bulged out around the equator (like on it’s way to being shaped like a pancake, but still mostly spherical).

2. Jupiter is brighter in the infrared than we expect. Describe how bright we would expect Jupiter to be. Why is it brighter than that?
   
   We expect Jupiter to simply radiate as a blackbody, heated by the light from the Sun. However, Jupiter is brighter in the infrared because it is still contracting and this gravitational contraction releases potential energy, heating up the interior.

3. List the four Galilean moons, in order of increasing distance from Jupiter. Describe how each moons distance from Jupiter effects its properties.
   
   Io, Europa, Ganymede, Callisto. The closer moons (Io especially) are being heated internally due to the tides caused by their proximity to Jupiter.

**Saturn**

1. Will the material in Saturn’s rings eventually form a new moon? Why or why not?
   
   No. The rings lie within Saturn’s Roche limit. Inside the Roche limit, gravitationally bound objects will be torn apart by Saturn’s gravity.

2. If you were planning to search for life on one of Saturns moons, would you send your probe to Titan or Enceladus? Why?
   
   Titan because the temperature on Titan is just right for methane to be able to be solid, liquid or gas (its ’triple point’) so methane may act as water does on Earth. Titan may have organic molecules on its surface, similar to those from which we think life evolved on Earth.
**Uranus**

1. How did astronomers discover Uranus ring system? How do the rings remain so narrow?
   The ring system of Uranus was discovered by occultation of stars. The rings are kept narrow by shepard moons orbiting close to the rings.

2. Uranus has a highly tipped orbit (98 degrees). Because of this fact, how would you expect the temperatures at the two poles to compare? How do they actually compare, as observed by Voyager 2?
   Since one pole is pointed at the Sun for decades and then the other pole is pointed at the Sun for decades as Uranus goes around in its orbit, you would expect there to be a big temperature difference between the poles. However, when Voyager 2 went by, it observed about the same temperature at both poles. This means that the atmosphere must be very dynamic so as to move air around enough to redistribute the energy from the Sun over the whole planet.

**Neptune**

1. How was Neptune discovered?
   By studying the orbit of Uranus, astronomers predicted that there must be another planet beyond Uranus perturbing its orbit.

2. What is so unusual about Neptune’s (and Uranus’ magnetic field)? What can this tell us about the source of the planets magnetism?
   The magnetic fields are very offset from the centers of the planets. This suggests that the magnetic fields are coming from some asymmetric shell of electrically conducting liquid material outside the planets’ cores.