Astronomy 2020 – Space Astronomy & Exploration **Fall 2020**
Homework #5 Due: Nov. 9, 2020

In questions 1-3 below, choose the best answer. Then explain your reasoning in a few complete sentences. Why is your answer correct?

1. (2 pts). Recent evidence suggests that Mars once had a global magnetic field. Assuming this is true, which of the following could explain why Mars today lacks a global magnetic field like that of Earth?
   a) Mars rotates much slower than Earth.
   b) Mars's interior has cooled so much its molten core layer no longer undergoes convection.
   c) The Martian core is made of rock, while Earth's core is made of metal.
   d) Mars is too far from the Sun to have a global magnetic field.

a) is incorrect because a day on Mars (24 hr, 37 min) is essentially the same as a day on Earth (24 hr).
b) is correct. Convection in metallic cores causes planetary magnetic fields.
c) is incorrect because if the Martian core was made of rock, Mars never would have had a magnetic field in the first place because convection in metallic cores causes planetary magnetic fields.
d) is incorrect because the Sun is irrelevant to planetary magnetic fields. Even a rogue planet (a planet with no star) could maintain a magnetic field if its core is warm enough to undergo convection.

2. (2 pts). Why does Venus have such a great difference in temperature between its "no atmosphere" temperature and its actual temperature?
   a. It has a slow rotation.
   b. It is so close to the Sun.
   c. It has a large amount of greenhouse gases in its atmosphere.
   d. It has a high level of volcanic activity.
   e. It has no cooling effects from oceans.

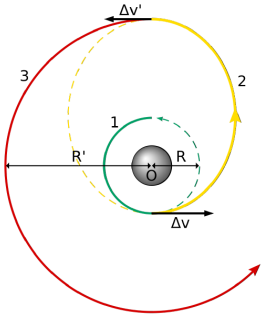
With no atmosphere, the temperature of a planet is driven by the amount of solar heating it experiences. With an atmosphere, like Venus, the atmosphere prevents infrared radiation or heat from escaping. In the case of Venus, it has a runaway Greenhouse Effect. Its atmosphere is mainly carbon dioxide, a highly effective Greenhouse gas, and very thick so it heats the surface of Venus to a much higher temperature than it would have without an atmosphere.

3. (2 pts). Volcanism is more likely on a planet that
   a. is closer to the Sun.
   b. is struck often by meteors and solar system debris.
   c. has high internal temperatures.
   d. doesn't have an atmosphere or oceans.

Volcanic magma flows are produced when internal planetary heat pushes molten lava to the

surface of a planet. The size of the planetary core determines how fast it cools so planets with larger cores will stay warm longer. The distance from the Sun (a) is not a factor in determining the internal temperature, only the surface temperature. Impacts (b) heat the surface briefly, not the interior. An atmosphere or ocean (d) does not play a role in heating the interior of a planet.

4. (6 pts). Discuss a human mission to Mars. Be sure to list the references where you obtained information to answer this question.
   a. (2 pts). Describe the orbital trajectory needed to get to Mars. Assume that Hohmann transfer orbits will be used.



Starting in the same orbit as the Earth's around the Sun, the spacecraft burns fuel in order to transfer to an elliptical orbit with its perihelion (closest to Sun) at Earth's orbit and its aphelion (furthest from Sun) at Mars' orbit. See diagram (Sun is at the center). A second rocket burn then places the spacecraft into a more circular orbit that coincides with Mars' orbit around the Sun.

   b. (1 pt). Estimate how long it will take to get to Mars. Justify your answer.

About 8.5 months using a Hohmann transfer orbit.

   c. (1 pt). Why would astronauts be forced to spend about a year on the surface of Mars before returning?

The Hohmann transfer orbit cannot be executed (successfully) at any time. Your destination planet must be in the correct position so that the spacecraft rendezvous with it when it reaches the planet's orbit. Roughly every 2 years Mars and Earth are correctly aligned for a launch.

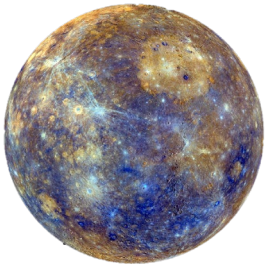
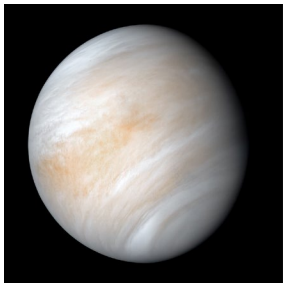
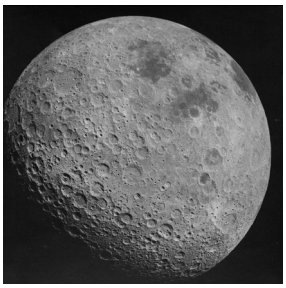
   d. (2 pts). What resources will be available on Mars to help astronauts to "live off the land" and what will need to be brought from Earth?

Astronauts will be able to harvest water (and, thus, make rocket fuel from water), oxygen, and metals for building materials from Mars. However, they will need to bring equipment to make extracting these materials possible, as well as a way to start food production (including a nitrogen-based fertilizer).

5. (3 pts). How do the size and chemical composition of a planet determine its internal temperature?

Size is the most important factor in determining how rapidly a planet loses its internal heat. The larger a planet is, the deeper is the "insulation" that surrounds the core and keeps in the heat. The chemical composition of a planet determines the amount of radioactive elements present. Currently the terrestrial planets' primary source of heat is radioactivity.

6. (3 pts). Explain why Mercury, Venus, and the Moon do not have significant erosion. Relate erosional activity to the planetary formation properties.

Mercury has a negligible atmosphere from the point of view of erosion, primarily due to its high temperature, related to its distance from the Sun. Its relatively small size also led to only a small amount of outgassing to form an atmosphere in the first place. The Moon also has a negligible atmosphere, primarily related to the inability of such a small world to create or retain an atmosphere. Venus has a great deal of atmosphere but very little erosion. Water erosion doesn't occur because the planet is too hot, related to its distance from the Sun. It lacks significant wind erosion because its slow rotation rate leads to very slow winds.

7. (3 pts). Earth and Venus both presumably had similar gases outgassed from their volcanoes. Briefly explain how their atmospheres ended up so different.

On Venus, water and carbon dioxide remained in the atmosphere. Over time, ultraviolet light split the water molecules and the hydrogen escaped to space. Thus, Venus has no more water today and an atmosphere thick with carbon dioxide. On Earth, water condensed to rain and eventually formed the oceans. Carbon dioxide was absorbed in the oceans and is now locked up in carbonate rocks. Thus, most of the water on Earth remains in the oceans, and most of the carbon dioxide is in rocks, leaving a much thinner atmosphere than that of Venus.