

# OpenStax Astronomy, Ch.7: WS Solutions (Apr-2021)

## Solutions

1. What is the difference between a differentiated body and an undifferentiated body, and how might that influence a body's ability to retain heat for the age of the solar system?

A differentiated body is one that has been heated to the point where it is liquid, and heavier, denser materials sink to the center of the planet, and the lighter elements rise to the outer layer. The concentration of materials helps to retain heat in the interior of a planet. Undifferentiated bodies were never heated enough for the elements to separate; they cool quickly and are typically smaller in size.

2. What does a planet need in order to retain an atmosphere? How does an atmosphere affect the surface of a planet and the ability of life to exist?

The gravity of a planet helps to determine whether an atmosphere can be retained. Mars has a shallow atmosphere compared to Earth, but it is also only 1/3 the size of Earth. Venus and Earth are about the same size and both have atmospheres. A dense atmosphere insulates the surface of a planet so that more heat is retained; however, the composition of the atmosphere is also important. Certain gases lead to a greenhouse effect, allowing the planet to be warmer than you would expect from its position around the Sun. Life as we know it requires temperatures and pressures at which water is liquid.

3. Which type of planets have the most moons? Where did these moons likely originate?

The giant planets have the most moons, especially Jupiter and Saturn. Many of them are thought to have been captured from the small-body population during the formation of the solar system.

4. What is the difference between a meteor and a meteorite?

Meteoroids that collide with Earth's atmosphere are called meteors. If the object makes it through the atmosphere and lands on the surface of Earth, then it is called a meteorite.

5. Explain our ideas about why the terrestrial planets are rocky and have less gas than the giant planets.

The terrestrial planets and the gas planets are thought to have formed under different conditions. The inner planets are made of elements that can survive the heat of the Sun; gases would have evaporated. The giant planets are far enough away that gases could accumulate around the planet cores and remain there for the age of the solar system.

6. Do all planetary systems look the same as our own?

No. Among the thousands of other planetary systems we have observed so far, systems have evolved along different evolutionary paths. Some have gas giant planets much closer to the Sun, for example.

7. What is comparative planetology and why is it useful to astronomers?

Comparative planetology is the study of how planets work and evolve by comparing them and the processes that have influenced their development. This method allows us to learn about the origin and evolution of the entire solar system, instead of each planet as a discrete object in space.



8. What changed in our understanding of the Moon and Moon-Earth system as a result of humans landing on the Moon's surface?

By landing on the surface of the Moon, we were able to collect surface samples and then use radiocarbon dating techniques to determine the age of the Moon. We were able to conclude that the Moon is dead geologically.



9. If Earth was to be hit by an extraterrestrial object, where in the solar system could it come from and how would we know its source region?

Earth could be hit by any of the small bodies in the solar system, most likely a comet or a near-Earth asteroid. We can tell the difference based on the orbit of its approach to Earth (if we found it in advance) and by its composition—whether it is primarily rocky or icy.

10. List some reasons that the study of the planets has progressed more in the past few decades than any other branch of astronomy.

The planets are relatively close to Earth (compared to the stars and galaxies), and technology has been developed that has allowed us to send spacecraft to all of the major planets and many other small worlds. Space missions to these bodies allow us to make close observations that we cannot obtain from Earth's surface or from telescopes in orbit around Earth. Spacecraft that land on other planets allow us to make in situ measurements of rocks and the lower atmosphere, and spacecraft that orbit other planets allow us to study surface geology (sometimes over time) as well as chemical composition of the atmosphere as a whole.

11. What characteristics do the worlds in our solar system have in common that lead astronomers to believe that they all formed from the same “mother cloud” (solar nebula)?

They generally revolve and rotate in the same direction, and their orbits lie in roughly the same plane. The chemical makeup of the giant planets is similar to the Sun.

12. How do terrestrial and giant planets differ? List as many ways as you can think of.

Terrestrial planets lie closer to the Sun. They are small compared to the giant planets, have relatively high densities, and are made of mostly silicates and metals. The giant planets lie farther from the Sun and are large compared to the terrestrial planets. They have relatively low overall densities, and large extended atmospheres and ice cores without a solid surface. The giant planets also have many more moons compared to the terrestrial planets.

13. Why are there so many craters on the Moon and so few on Earth?

The Moon does not have an active geological cycle, so craters are not destroyed; they are preserved since the time of their formation. Earth has active weathering as well as continuing geological activity that constantly recycles its surface. Fundamentally, this is because Earth still has an active heat source at its core while the Moon has cooled. Earth also has an atmosphere that causes the breakup and destruction of smaller meteors, whereas the Moon does not block even the smallest cosmic pieces from hitting its surface.

14. How do asteroids and comets differ?

Asteroids are composed primarily of rock and metal and reside in the inner part of the solar system. Comets are typically icy objects that come from the outer solar system and become visible as they get closer to the Sun and the ice evaporates (sublimes) as a result of heating. Asteroids tend to have greater densities than comets.

15. How and why is Earth's Moon different from the larger moons of the giant planets?

Earth's Moon is not geologically active compared to some of the larger moons of the giant planets, and it resides relatively close to the Sun, so its composition is primarily rocky. In contrast, the moons of the giant planets have a significant fraction of ice.





16. Where would you look for some “original” planetesimals left over from the formation of our solar system?

Small asteroids, comets, Kuiper Belt objects, and small moons were likely never heated enough to be differentiated; therefore, their chemical makeup and structure are more representative of their origin. They are found at a variety of distances from the Sun, so they can inform us about the entire structure of the solar system.

17. What can we learn about the formation of our solar system by studying other stars? Explain.

Other star systems allow us to see the different paths that the formation of planetary systems might take from the outside, as well as observe planetary systems that are at different stages in their formation process. In places such as the Orion Nebula, we are seeing other examples of the solar nebula that gave birth to the Sun and the planets. Around other stars, we also see examples of planetary systems that resemble our own.

18. Explain why the planet Venus is differentiated, but asteroid Fraknoi, a very boring and small member of the asteroid belt, is not.

A planet differentiates when its interior temperature rises above the melting point of the material it is made up of. Massive planets such as Venus are heated by radioactivity and by the energy of impacts as they form. Because it is difficult for this heat to escape, the temperature rises. They therefore melt, and heavier materials sink to the center. A small asteroid such as Fraknoi, in contrast, loses its energy quickly and retains a cold interior.

19. Would you expect as many impact craters per unit area on the surface of Venus as on the surface of Mars? Why or why not?

Because of its dense atmosphere, Venus is protected from smaller cratering impacts. Smaller chunks of material vaporize completely as they pass through its atmosphere. Thus, the smallest craters of Venus are several kilometers in diameter, whereas Mars (with only a thin atmosphere) has thousands of craters smaller than this. The other factor is the retention of craters. Venus appears to have been active geologically more recently than Mars, so its craters were destroyed more quickly. For both reasons, Venus has fewer craters.

