

PHYS#215 - CH#6 - Q&A

Monday, April 26, 2021 10:30 AM

Concept Review

The [terrestrial planets](#), the four inner planets, are rocky worlds. Venus and Earth have similar sizes, masses, and densities, but are otherwise very different. Mercury and Mars are about a third and a half of Earth's diameter, respectively. Compared with the giant planets we will discuss in the [next chapter](#), the terrestrial planets are smaller, rocky, and dense, and they have fewer moons and no rings. [Comparative planetology](#) has applications for understanding weather, earthquakes, and other topics of use to us on Earth ([Section 6.1](#)).

[Geology](#) is the study of the Earth's interior and surface, and often uses [seismology](#), the study of waves that pass through Earth, to study Earth's interior ([Section 6.1a](#)). Earth has a layered structure, with a [core](#), [mantle](#), and [crust](#). Radioactivity heats the interior, producing molten rock known as [magma](#) (or [lava](#), if it reaches Earth's surface) and providing [geothermal energy](#) ([Section 6.1b](#)). Continental [plates](#) move around the surface, as explained by [plate tectonics](#), the current theory that elaborates on the earlier notion of [continental drift](#).

[Tides](#) are a [differential force](#) caused by the fact that the near side of Earth is closer to the Moon than Earth's center, and so is subject to higher gravity, while the far side is farther than the center and is subject to lower gravity ([Section 6.1c](#)).

Earth's weather is confined in its atmosphere to the [troposphere](#) ([Section 6.1d](#)). The atmosphere and surface of Earth are substantially warmer than they would have been without the [greenhouse effect](#). In the [ionosphere](#), atoms are ionized and the temperature is higher. The [Van Allen belts](#) of charged particles were a space-age discovery ([Section 6.1e](#)). Such particles lead to the [aurora borealis](#) and [aurora australis](#), the northern and southern lights.

Our own Moon is midway in size between Pluto and Mercury. Its volcanic surface shows smooth [maria](#) (singular: **mare**) and cratered [highlands](#) ([Section 6.2a](#)). Shadows reveal relief best along the [terminator](#), the day–night line. Most of the craters are from meteoritic impacts ([Section 6.2b](#)). The oldest rocks are from 4.4 billion years ago; on Earth, erosion and plate tectonics have erased most of the oldest rocks, though a few nearly equally old terrestrial rocks have been found. [Mascons](#) are mass concentrations of high density under the Moon's surface ([Section 6.2c](#)). The current leading model for the Moon's formation is that a body perhaps twice the size of Mars hit the proto-Earth, ejecting matter into a ring that coalesced ([Section 6.2d](#)). A handful of meteorites found on Earth have been identified by their chemical composition as having come from the Moon ([Section 6.2e](#)).

Mercury always appears close to the Sun in the sky; rarely it even goes into [transit](#) across the Sun's disk ([Section 6.3](#)). The correct rotation period of Mercury was first

measured using radar and proved to be linked to its orbital period ([Section 6.3a](#)). Like the Moon, Mercury has a dark (low [albedo](#)) surface ([Section 6.3b](#)). Mercury is heavily cratered, and shows [scarps](#) that resulted from a planet-wide shrinkage ([Section 6.3c](#)).

Mercury has a weak magnetic field and is the only planet besides Earth to have magnetized poles. It is too close to the Sun to retain a thick atmosphere, but a very thin atmosphere does exist ([Section 6.3d](#)). NASA's MESSENGER spacecraft entered orbit around Mercury in 2011 and, until it crashed into Mercury's surface in 2015, redefined our understanding of the planet ([Section 6.3f](#)).

In 2004 and 2012, Venus transited the Sun as seen from Earth, for the first pair of transits in over 100 years ([Section 6.4a](#)); the next pair of transits of Venus won't occur until 2117 and 2125. The highly reflective clouds that shroud Venus, giving it a high albedo, are mainly droplets of sulfuric acid, though the atmosphere consists primarily of carbon dioxide ([Section 6.4b](#)). Venus's atmospheric surface pressure is about 90 times higher than Earth's. Radar penetrated Venus's clouds to show that Venus is rotating slowly backward and to map its surface ([Section 6.4c](#)).

Venus's surface temperature is very high, about 750 K, heated by the greenhouse effect ([Section 6.4d](#)). Earth escaped such a fate, but we should be careful about disrupting the balance in our atmosphere, lest conditions change too quickly. The atmosphere of Venus has been

studied with various spacecraft ([Section 6.4e](#)). Radar is used to map the surface of Venus ([Section 6.4f](#)). Higher-resolution radar reveals smaller surface features. ESA's Venus Express spacecraft orbited Venus during 2006–2014; Japan's Akatsuki ("Dawn") has orbited since 2015 ([Section 6.4g](#)).

Stories about life on Mars have long inspired study of this planet. We now know the seasonal surface changes to be the direct result of winds that arise as the sunlight hits the planet at different angles over a martian year ([Section 6.5a](#)). Mars's weather and dust storms help us understand our own weather. Mars appears reddish-orange in the sky because of rusty dust on its surface; however, careful calibration of photos taken on Mars itself shows that the soil is actually yellowish-brown.

Mars boasts of giant volcanoes and a canyon longer than the width of the continental United States ([Section 6.5b](#)). There is strong evidence that Mars had liquid water flowing on its surface long ago. Mars's current atmosphere is very thin, with a surface pressure less than 1 per cent of that near Earth's surface ([Section 6.5c](#)). But long ago, up to about a billion years after it formed, Mars had a thicker atmosphere and a hospitable climate.

In the 1970s, the Viking landers found no conclusive evidence for life on Mars, despite initially promising signs ([Section 6.5d](#)). Studies of a martian meteorite that was found in Antarctica provided suggestive, but not convincing, evidence for the presence of ancient, primitive life on Mars.

Mars Science Laboratory, nicknamed Curiosity, landed on Mars in 2012 with the most ambitious set of instruments yet to search for the conditions needed for life ([Section 6.5e](#)).

Crewed missions to Mars should happen eventually, but probably not for decades because of their cost and difficulty ([Section 6.5f](#)).

Questions

1. How did the layers of Earth arise? Where did the energy that is flowing as heat come from?
2. What carries the continental plates around over Earth's surface?
3. **(a)** Explain the origin of tides. **(b)** If the Moon were farther away from Earth than it actually is, how would tides be affected?
4. Draw a diagram showing the positions of Earth, the Moon, and the Sun at a time when there is the least difference between high and low tides.
- †5. Calculate your weight if you were standing on the Moon.
6. Look at a globe and make a list or sketches of which pieces of the various continents probably lined up with each other before the continents drifted apart.
7. To what locations, relative to the Earth–Sun line, does Earth's terminator correspond?
8. What does cratering tell you about the age of the surface of the Moon, compared to that of Earth's surface?
9. Why are we more likely to learn about the early history of Earth by studying the rocks from the Moon than those on Earth?

- 10.** Why may the near side and far side of the Moon look different?
- 11.** Discuss one of the proposed theories for the origin of the Moon. List points both pro and con.
- 12.** How can we get lunar material to study on Earth?
- 13.** Assume that on a given day, Mercury sets after the Sun. Draw a diagram, or a few diagrams, to show that the height of Mercury above the horizon depends on the angle that the Sun's path in the sky makes with the horizon as the Sun sets. Discuss how this depends on the latitude or longitude of the observer.
- 14.** If Mercury did always keep the same side toward the Sun, would that mean that the night side would always face the same stars? Draw a diagram to illustrate your answer.
- 15.** Explain why a day/night cycle on Mercury is 176 Earth day/night cycles long.
- 16.** What did radar tell us about Mercury? How did it do so?
- 17.** If ice has an albedo of 70–80 per cent, and volcanic rocks typically have albedos of 5–20 per cent, what can you say about the surface of Mercury based on its measured albedo?
- 18.** If you increased the albedo of Mercury, would its surface temperature increase or decrease? Explain.
- 19.** How would you distinguish an old crater from a new one?

- 20.** What evidence is there for erosion on Mercury? Does this mean there must have been water on the surface?
- 21.** List three major discoveries of Mariner 10. List three improved results found by MESSENGER.
- 22.** Make a table displaying the major similarities and differences between Earth and Venus.
- 23.** Why does Venus have more carbon dioxide in its atmosphere than does Earth?
- 24.** Why do we think that there have been significant external effects on the rotation of Venus?
- 25.** Suppose a planet had an atmosphere that was opaque in the visible but transparent in the infrared. Describe how the effect of this type of atmosphere on the planet's temperature differs from the greenhouse effect.
- 26.** Why do radar observations of Venus provide more data about the surface structure than a flyby with close-up optical cameras?
- 27.** Why do we sometimes say that Venus is Earth's "sister planet"?
- 28.** Describe the most current radar observations of Venus.
- 29.** What are some signs of volcanism on Venus?
- 30.** List three of the features of Mars that made scientists think that it was a good place to search for life.

- †31. Compare the tallest volcanoes on Earth and Mars relative to the diameters of the planets. Give the ratios.
32. What evidence exists that there is, or has been, water on Mars?
33. Describe the composition of Mars's polar caps.
34. Consult an atlas and compare the sizes of the Grand Canyon in Arizona and the Rift Valley in Africa. How do they compare in size with the giant canyon on Mars?
35. Compare the temperature ranges on Venus, Earth, and Mars.
36. List the evidence from Mars landers for and against the existence of life on Mars.
37. Plan a set of experiments or observations that you, as a martian scientist, would have an uncrewed spacecraft carry out on Earth to find out if life existed here. What data would your spacecraft radio back if it landed in a cornfield? In the Sahara? In the Antarctic? In New York's Times Square?
38. **True or false?** All four terrestrial planets show evidence of water flowing on their surfaces, either now or in the distant past.
39. **True or false?** From Earth, neither Mercury nor Venus can be seen high in the sky at midnight.
40. **True or false?** Earth's Moon has a composition similar but not identical to that of Earth's crust, consistent with the

hypothesis that the Moon formed after a large object collided with Earth.

41. True or false? At any given coastal location on Earth, high tide occurs only once per day, when the Moon is overhead.

42. True or false? Venus's surface is exceptionally hot primarily because its atmosphere traps x-rays and ultraviolet radiation from the Sun.

43. True or false? The terrestrial planets have iron cores and rocky outer parts; the iron sank when they were young and molten.

44. True or false? Of the four terrestrial planets, Earth is the only one that now has obvious plate tectonics.

45. True or false? We see a lot more impact craters on the Moon's surface than on Earth's surface; thus, the Moon's surface is older, and the Moon formed earlier than Earth did.

46. True or false? You would weigh the same as you do now on Earth if Earth were twice as large (in diameter) *and* four times as massive.

47. True or false? If you were standing at a fixed location on the Moon, you would see Earth rise above one horizon and set some time later on the opposite horizon.

48. True or false? The water which is thought to have once flowed on Mars but did not escape from the planet as a gas is

now locked primarily in permafrost and polar caps.

†49. Multiple choice: If you are at the beach and the full moon is just starting to rise above the eastern horizon, it is most likely that you will see low tide (or close to low tide) in about **(a)** 3 hours; **(b)** 6 hours; **(c)** 9 hours; **(d)** 12 hours; or **(e)** 15 hours.

50. Multiple choice: Astronomers have observed that the Moon is more heavily cratered than Earth. This is primarily because **(a)** the Moon is more distant than Earth, causing incoming rocks to hit it first; **(b)** the Moon is much more deficient in iron relative to Earth, causing craters to form more easily; **(c)** the Moon has been around longer than Earth and has been exposed to more periods of meteor bombardment; **(d)** the Moon experiences almost no erosion compared to Earth, causing craters to remain much longer; or **(e)** the Moon experiences frequent volcanic eruptions that cause craters.

51. Multiple choice: Which one of the following statements about the greenhouse effect, Venus, and Earth is *false*? **(a)** An extreme, possibly runaway, greenhouse effect occurred on Venus, making its planetary surface the hottest in the Solar System. **(b)** Venus's atmosphere is much thicker than that of Earth – but some of Earth's gases are trapped in rocks and oceans. **(c)** If we dump much more carbon dioxide into Earth's atmosphere, the greenhouse effect might make the Earth significantly hotter. **(d)** The greenhouse effect occurs when an atmosphere is largely transparent to optical (visible)

light but mostly opaque to infrared light. **(e)** No greenhouse effect currently occurs on Earth, and this is a good thing for humans.

†52. Multiple choice: If Earth's radius suddenly shrank by a factor of 2 but Earth's mass remained unchanged, how much would you weigh while standing on the new (smaller) surface of Earth? **(a)** 16 times as much. **(b)** 4 times as much. **(c)** Twice as much. **(d)** Half as much. **(e)** Your weight would remain unchanged.

53. Multiple choice: Which one of the following statements about the Earth–Moon system is *true*? **(a)** The same half of the Moon's surface is perpetually dark (craters on that side never see sunlight), leading us to call it the “dark side of the Moon.” **(b)** At a given location on Earth, there are two high tides each day – one caused by the gravitational pull of the Sun, and the other by the gravitational pull of the Moon. **(c)** High tide occurs on the side of Earth nearest to the Moon, while low tide occurs on the opposite side of Earth. **(d)** By observing the Moon long enough from Earth, night after night, we are able to draw a map of its entire surface. **(e)** The orbital period of the Moon around Earth and the rotation period of the Moon around its axis are equal.

54. Multiple choice: Why does Mars appear reddish-orange from Earth? **(a)** Its surface temperature is lower than that of the Earth, which appears blue, and according to Wien's law Mars is therefore redder. **(b)** Its thick atmosphere consists of

reddish-orange clouds. **(c)** Its rocks have suffered “rusting” and contain iron oxides which appear reddish-orange against the dark sky. **(d)** It is moving away from us rapidly and hence is Doppler redshifted. **(e)** There is a large population of martians wandering around, and they tend to have a reddish-orange skin color.

55. Multiple choice: The surface of Venus is best observed using **(a)** ultraviolet satellites; **(b)** radar; **(c)** large optical telescopes; **(d)** large radio telescopes; or **(e)** infrared telescopes.

56. Multiple choice: Which one of the following statements about the terrestrial planets is *false*? **(a)** Earth’s atmosphere plays a central role in keeping our planet from freezing cold temperatures. **(b)** Venus is the hottest planet in our Solar System, mainly the result of a greatly elevated greenhouse effect. **(c)** Long ago, Mars probably had a thicker atmosphere than it does now, with sufficiently high temperatures and pressures to allow liquid water to exist on its surface. **(d)** Earth’s atmosphere allows the Sun’s infrared radiation in but doesn’t allow much visible light to escape, resulting in the greenhouse effect. **(e)** Despite being the closest planet to the Sun, some parts of Mercury have a surface temperature far below the freezing point of water.

57. Multiple choice: Which one of the following choices gives the correct ranking, from greatest to smallest, of the gravitational force exerted by the Moon on Earth? (Note that

“near side” means the side of Earth closest to the Moon, “center” means the center of Earth, and “far side” means the side of Earth farthest from the Moon.) **(a)** The force is the same everywhere. **(b)** Near side, center, far side. **(c)** Far side, center, near side. **(d)** Center is greatest; near side and far side are the same but less. **(e)** Impossible to say without more information.

58. Multiple choice: If you were on the Moon and continued to stand at the same location, **(a)** the daytime sky would be blue, and sunset would occur approximately every 24 hours; **(b)** the daytime sky would be black, and sunset would occur approximately every 24 hours; **(c)** the daytime sky would be blue, and sunset would occur approximately every 30 days; **(d)** the daytime sky would be black, and sunset would occur approximately every 30 days; or **(e)** sunset would never occur because half of the Moon is always bright and the other half is always dark.

59. Fill in the blank: Earth's ^{AURORAS} _____ occur in regions where Earth's magnetic field lines intersect its atmosphere, as a result of collisions between charged particles and air molecules.

60. Fill in the blank: The lunar ^{Maria} _____ must have formed more recently than the cratered highlands, covering up older craters.

61. Fill in the blank: Venus is often seen as the brightest evening or morning “star” in the sky, in part because it is shrouded in highly reflective clouds.

62. Fill in the blank: A planet is said to be in Transit when it appears to move across the face of the Sun.

63. Fill in the blank: The process of forming layers within a planet, because of differences in density between materials, is called differentiation. †This question requires a numerical solution.