Exam 3 Review Problems

Note: The letters following the number indicate where the question is from, i.e., class (c), online quiz (q), or another source (b).

Chapter 10 (Lectures 17 and 18) Review Questions

Keywords: capture theory, co-creation theory, collisional ejection theory, crater, far side (of the Moon), fission theory, impact crater, synchronous rotation, terminator, moonquake, mare (*plural* maria)

3q. A fundamental process that shaped the Moon's surface was

(a) impacts of asteroidal debris onto a hard, immobile crust.

(b) the formation of solid crustal plates that collide or move past each other in response to molten rock rising between them.

(c) heat from the Moon's interior keeping the crust soft so that it can be deformed easily by convection currents in the Moon's interior.

4q. Over geologic time, plate tectonics has been the dominant process shaping the surface of the Earth. In comparison, what plate tectonic features do we see on the surface of the Moon?

(a) Ongoing creation of new crust along ridges (similar to Earth's Mid-Atlantic ridge), with crustal subduction at deep trenches along plate boundaries.

(b) None at all.

(c) Ancient chains of mountains due to compression at plate boundaries early in the life of the Moon, but no currently moving plates or subduction zones.

5q. The Moon's surface appears to be split into two distinct hemispheres, one containing numerous dark circular basins or maria, the other consisting mainly of light-colored highlands and only one small mare. Which segment of the Earth's population has seen this latter hemisphere?

(a) Only the Apollo astronauts.

(b) Everyone because this is the hemisphere facing the Earth.

(c) The inhabitants of the Earth's southern hemisphere because this lunar region can be seen only from there.

6q. The majority of the craters on the Moon were caused by

(a) impact of meteoritic material upon the surface.

(b) explosive melting and boiling of frozen water from beneath the lunar surface under intense sunlight, leaving dried-up lakes as craters.

(c) eruption of ancient volcanos, leaving central calderas.

7q. How do we know the lunar maria (or "seas") are younger than the lunar highlands?

(a) The maria have relatively few craters, whereas the highlands are very densely cratered from long exposure to incoming meteoroids.

(b) The maria are still dark, whereas the highlands have been lightened by a much longer exposure to radiation from the Sun.

(c) The maria are lower in elevation, whereas the highlands have had time to be uplifted by tectonic processes.

8q. Most of the mountains on the Moon are

(a) the raised rims of ancient impact craters and maria.

(b) upthrust zones between tectonic plates as they move and collide in the lunar surface.

(c) regions of hard rock left behind after erosion of softer material by massive flooding early in the Moon's history.

11q. Evidence for water on the Moon has recently been discovered in the form of

(a) ice, in deep craters at the north and south poles, perpetually shaded from sunlight.

(b) fluid water, flowing in deep tunnels, some of which have collapsed to form the rilles on the lunar surface.

(c) thin, hazy clouds overlying the dark polar regions where they are shaded from sunlight.

12q. What have we learned about the Moon's global magnetic field?

(a) The Moon has no global magnetic field at the present time, but did have early in its life.

(b) The Moon's global magnetic field is weaker than that of the Earth, but is still strong enough to repel the solar wind.

(c) The Moon has never had a global magnetic field.

14q. How does the lunar lithosphere (the crust and solid, outer part of the mantle) compare to that of the Earth?

(a) The lunar lithosphere is only one-third to one-quarter as thick as that of the Earth.

(b) The lunar lithosphere is two to three times thicker than that of the Earth.

(c) The lunar lithosphere is eight or more times thicker than that of the Earth.

15q. Compared to earthquakes on Earth, moonquakes are
(a) far more frequent but far weaker in intensity.
(b) much less frequent but much more destructive.
(c) much less frequent and far less intense.
16q. Moonquakes appear to be more frequent
(a) when the Moon is near perigee (closest to the Earth).
(b) when the Sun is highest in the lunar sky.
(c) at Full Moon.
19q. The ages of lunar rocks, brought back to Earth by astronauts and robotic spacecraft, have been determined by
(a) the measurement of the numbers and thicknesses of layers within the sedimentary rocks, laid down during the original formation of the Moon.
(b) the measurement of relative radioactive element concentrations.
(c) the measurement of the relative numbers of microcraters on the rock surfaces.
21q. What has happened to the rate of impact cratering on the Moon over the Moon's history?
(a) It tapered off very quickly from a high value when the Moon first formed to a very low cratering rate less than a billion years later, remaining very low ever since.
(b) It has remained almost steady since the Moon first formed.
(c) It tapered off slowly, being very high when the Moon was young, roughly half that when the Moon was half its present age, and quite low now.
22q. During what part of the geological history of the Moon did the lava flows occur that we now see as the lunar maria?
(a) Between 4.5 and 3.8 billion years ago, during the heavy bombardment phase when asteroids and other objects were hitting the Moon.
(b) Between 3.8 and 3.1 billion years ago, at or just after the end of the heavy bombardment phase.
(c) Between 2.4 and 1.7 billion years ago, when heating by radioactive elements melted the mantle material under the lunar crust.
25q. The origin of the Moon in the early history of the solar system appears to have been
(a) the fission of the early molten Earth into two objects by gravitational disturbance within the solar nebula.
(b) the ejection of debris from a collision of a planet-sized object with the Earth, and subsequent coalescence into the Moon.
(c) the capture of an interplanetary wanderer by the Earth's gravitational field.

1b. The terminator on the Moon is a line
A) joining north and south lunar poles, passing through the center of the largest mare, Imbrium, representing 0° of lunar longitude.
B) between the near and far sides of the Moon.
C) between the solar-illuminated and dark hemispheres.
D) along the equator, between northern and southern hemispheres.

2b. The diameter of the Moon is
A) less than 1/100 of the diameter of the Earth.
B) about 1/10 of the diameter of the Earth.
C) about 1/4 of the diameter of the Earth.
D) just over 1/2 the diameter of the Earth.

3b. People on Earth see
A) only the sunlit side of the Moon.
B) the same side of the Moon at all times.
C) the entire Moon once each month as it rotates.
D) the entire surface of the Moon once per year as the Earth revolves around the Sun.

4b. To observers on Earth, the Moon shows
A) only its northern half because of the tilt of the Moon's rotational axis.
B) its whole surface once per month as it rotates.
C) only one side to Earth at all times.
D) its whole surface once per year as Earth moves around the Sun.

6b. The rotation period of the Moon on its axis with respect to space (its absolute rotation) is
A) infinitely long, because the Moon never rotates.
B) 27.3 days, the sidereal revolution period.

C) 365.25 days, to match Earth's revolution period.
D) 29.5 days, the synodic period.

7b. If viewed from a point directly above the plane of the planetary system, how would the Moon appear to rotate on its axis?
A) It would rotate once per year as Earth and Moon orbit the Sun together.
B) It would not rotate at all, because we always see the same face on Earth.
C) It would rotate once per day, to maintain its direction toward Earth.
D) It would rotate once per month, or once per revolution about Earth.

10b. Which of the following general statements about the Moon is true?
A) There is one side of the Moon from which Earth can never be seen.
B) The Moon does not rotate on its axis.
C) There is one side of the Moon from which the Sun can never be seen.
D) One side of the Moon is always in darkness.

11b. If you were standing on the Moon with Earth in view, how much time would elapse between two successive "Earthrises"?
A) about 1 synodic month
B) about 1 day
C) about 1 sidereal month
D) infinite time, because the same side of the Moon always faces toward Earth

15b. If astronauts set up a permanent settlement at Tranquility Base on the Moon, how many times each year would the Sun rise and set as seen by a resident of this base?
A) 365 times each year
B) once each year
C) never—the Sun would remain motionless in the sky
D) about once per month

16b. Astronauts at a Moon base visible from Earth will NOT see
A) one side of Earth, because the Moon revolves at the same rate as Earth rotates.
B) sunrise or sunset, because the Sun will always remain in their sky.
C) the stars moving through their sky, because the Moon does not rotate.
D) Earthrise or Earthset.

28b. What are the most common shapes of lunar craters and why?
A) round, because the shock wave from the impact that produced them spread out uniformly in all directions
B) random shapes, because mantle convection has deformed the surface and distorted the craters since their production by impacts of meteoroids
C) all shapes from round to long and thin, depending on the angle at which the projectile hit the surface
D) round, because most of the craters were produced by volcanic explosions which formed calderas, not by meteoroid impacts

29b. Maria are
A) bright streaks radiating away from young, fresh craters.
B) isolated regions of heavily cratered highland terrain.
C) long, sinuous valleys formed by ancient lava rivers.
D) ancient lava floodplains.

30b. Maria are
A) large impact craters in-filled by lava.
B) ancient lake beds, now dry.
C) uplifted regions surrounding large shield volcanoes.
D) heavily cratered highland regions.

31b. A mare on the Moon is a
A) large crater with a central peak terracing along the crater walls.
B) crater shaped like a horse.
C) large area of dark material on the lunar surface.
D) large area of light material on the lunar surface.

51b. The impact craters on Earth are younger than a few million years old, whereas ages of lunar craters extend back billions of years. Why is this?
A) Earth escaped the heavy bombardment that pelted the Moon early in its history.

B) Earth's surface has been covered by lava flows several times in its history, whereas such activity ceased on the Moon several million years ago.
C) Weathering by rain and melting snow gradually erases craters on Earth, and this does not happen on the Moon.
D) Plate tectonics has erased older craters on Earth, whereas this process has not occurred on the Moon.

124b. Before the Mars-sized impactor struck the Earth to cause ejecta which formed he Moon, the Earth probably had a
A) smaller density and slower rotation rate than it does now.
B) smaller density and faster rotation rate than it does now.
C) greater density and slower rotation rate than it does now.
D) greater density and faster rotation rate than it does now.

125b. Which of the following is believed to be the correct explanation for the origin of the Moon?
A) The Moon was formed elsewhere in the solar system (which is why its composition differs from that of the Earth) and was later captured by the Earth's gravity.
B) Shortly after its formation, the Earth was spinning so fast in its molten state that a large piece of material was thrown off, and this coalesced to form the Moon—leaving the Pacific Ocean Basin in the place where it was thrown off.
C) The Earth and Moon were formed separately at the same time, while in orbit around their common center of mass, by the accretion of planetesimals.
D) The Earth was struck by a large planetesima, which caused material to be ejected. This material coalesced to form the Moon.

121b. Which one of the following four theories about the origin of the Moon is now believed to be correct?
A) An object about the size of Mars crashed into Earth and debris from the collision formed the Moon.
B) Earth and the Moon formed together, already orbiting each other.
C) The Moon formed separately in a different part of the solar nebula and was later captured by Earth.
D) Earth was spinning so rapidly while still molten that a piece "spun off" to form the Moon.

119b. Although we do not yet know precisely how the Moon was formed, an important clue is provided by the fact that
A) moon rocks resemble material similar to that in the interior of Earth.
B) the Moon is heavily cratered.
C) moon rocks resemble rocks close to the surface of Earth.
D) moon rocks contain significant amounts of water and other volatile substances.

118b. The theory that seems to account most satisfactorily for the origin of the Moon at the present time is that
A) the Moon formed from material spun off from Earth when Earth was molten and spinning rapidly, early in its history.
B) a large object collided with Earth and ejected the material that formed the Moon.
C) the Moon formed by accretion elsewhere in the solar system and was captured later by Earth.
D) the Moon formed from material already in orbit around Earth.

116b. One theory about the origin of the Moon says that the Moon was formed from debris thrown out when a Mars-sized object collided with Earth. One fact that strongly supports this theory is that
A) the Moon has several smooth plains formed by ancient lava flows.
B) the Moon always turns the same side toward Earth.
C) impact breccias (rock fragments cemented together by an impact) are common on the Moon.
D) Moon rocks are very similar to those of Earth but are depleted in elements that melt at relatively low temperatures.

1class. Figure 1 shows the rate of crater-making impacts as a function of time. If at 2 billion years ago the rate of crater-making impacts started to increase again, what would be different about how the moon looked?
(a) asteroids that struck the moon at an angle would create craters with more material on one side than the other, because the moon was drier
(b) asteroids that struck the maria would only leave a small mark because they reflect off the hard surface that make up the maria
(c) the maria would have more craters
(d) the maria would have fewer craters

2class. When is the far side of the moon the same as and the dark side of the moon?

(a) Always
(b) Once per year
(c) Twice per month
(d) Once per month
(e) At new moon

3class. What is the fission theory of the formation of the moon?

(a) The theory that the dark spots of maria are created by lava flows
(b) The theory that the moon was created by lava ejected into space by a volcano on Earth
(c) The theory that the moon was created when a chunk of Earth tore off and started orbiting.
(d) The theory that the moon and Earth were co-created
(e) The theory of evolution of the moon proposed by Darwin

4class What is synchronous motion?

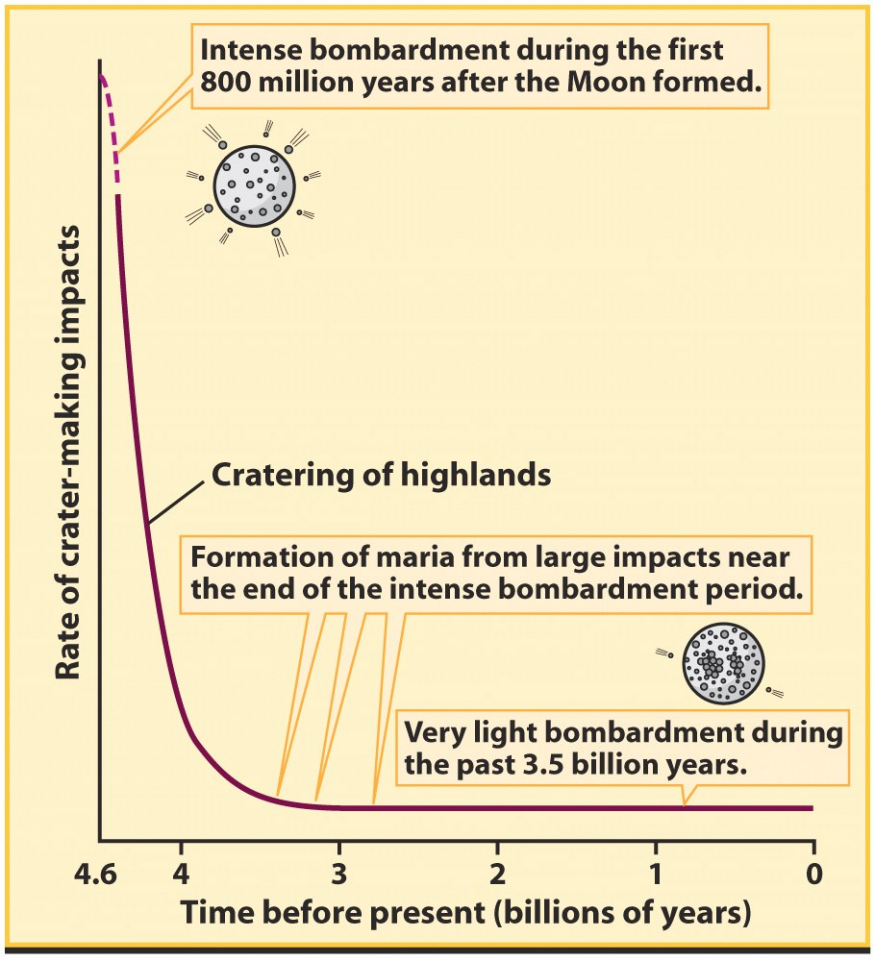

Figure 1.

Chapter 11 (Lecture 18) Review Questions

Keywords: greatest eastern elongation, greatest western elongation, solar transit, 1-to-1 spin-orbit coupling, 3-to-2 spin-orbit coupling, scarp

1q. A colleague tells you that she was outside at midnight and saw Mercury at opposition in the southern sky, from her position in the northern hemisphere. Do you have any reason to question this statement?

A) Yes. But only the direction in which she saw Mercury. This planet, when at opposition, appears in the northern sky.
B) Yes. Because Mercury never reaches the position of opposition and can never be seen at midnight.
C) No. Because opposition is the best configuration at which to see Mercury and the sky is darkest at midnight.

2q. Mercury's surface

A) has a variable albedo, reflecting different amounts of sunlight depending upon which hemisphere is illuminated.

B) has a very high albedo, hence its intense brightness at certain times in its orbit.
C) has a very low albedo, reflecting very little sunlight.

3q. Mercury has an albedo of only 12%, which means that it reflects only this percentage of sunlight falling on it. Why then does Mercury appear to be among the brightest objects in our sky?

A) Because it is so close to the Sun that it is heated to the point where it emits light as well as reflecting it.
B) Because we always see Mercury close to the horizon just after sunset or just before sunrise and this geometry, where the planet is viewed in twilight, appears to enhance its brightness.
C) Because it is close to the Sun and the Sun shines very intensely on it.

Section 11-2

8q. The difference in temperatures between the illuminated and dark sides of Mercury is

A) extreme because of Mercury's specific rotational period and the lack of an atmosphere.
B) relatively small because Mercury's atmosphere spreads the heat to the cold hemisphere.
C) relatively small because the high thermal conductivity of the planet's surface ensures that heat is quickly distributed around the planet.

9q. The temperature on the dark side of Mercury is warmer than would be expected if that side of Mercury always faced away from the Sun. The reason for this is that

A) atmospheric winds circulate air between the sunlit side and the dark side, warming the dark side and cooling the sunlit side.
B) Mercury rotates about its own axis in a shorter time than it revolves around the Sun, so all parts of Mercury face the Sun at some time during each orbit.
C) Mercury does not rotate about its axis, so the side which faces away from the Sun at any one time faces toward the Sun half an orbit later.

14q. Mercury looks very similar to which planet or satellite in our solar system?

A) Venus because of the thick clouds that hide the surface from view.
B) Mars because of its volcanoes and extensive plains.
C) Our Moon because of all the craters.

1b. Mercury can be characterized as having

A) a Moon-like surface and an Earth-like interior.
B) both surface and interior like that of the Moon.
C) an Earth-like surface and a Moon-like surface.
D) a surface and interior significantly different from either the Moon or Earth.

3b. When Mercury is at its greatest western elongation, it is seen to the

A) east of the Sun in our post-sunset sky.
B) west of the Sun in our predawn sky.
C) east of the Sun in our predawn sky.
D) west of the Sun in our post-sunset sky.

4b. Mercury can be seen most easily from Earth

A) near the Sun, just after sunset or just before sunrise.
B) during a lunar eclipse, when the sky is sufficiently dark near the Moon, because Mercury is always close to the Moon in our sky.
C) in the winter, when the ecliptic plane is high in the sky at night.
D) at midnight, when it is high in the sky.

5b. A friend who says that he is an astronomer claims that he was outside at midnight a few weeks ago looking at Mercury. What should be your response?

A) Oh, you must have been in Australia or South America since Mercury can be seen at midnight only from the southern hemisphere."
B) "You must be mistaken, because Mercury NEVER appears in our midnight sky."
C) "Really! Have you just purchased a new telescope? Mercury can be seen at midnight only through a telescope."
D) "Congratulations, you have been fortunate enough to see Mercury on a very rare occasion."

6b. It is relatively difficult to observe details on the surface of Mercury from Earth because

A) detail is obscured by bright glows from hot regions of molten surface heated by the intense sunlight.
B) its orbit always keeps it on the opposite side of the Sun from Earth.
C) it is a small object that always appears close to the Sun in the sky.
D) its surface is always completely covered in clouds.

12b. How often does a solar transit of Mercury—Mercury passing directly across the face of the Sun as seen from Earth—occur?
A) regularly, once every synodic period of Mercury, or every 116 days
B) never
C) regularly, every sidereal period of Mercury, or every 88 days
D) relatively infrequently—between 10 and 20 times per century

23b. How many times will Mercury rotate with respect to the Sun in one sidereal orbital period?
A) 1/2 rotation
B) once
C) many times, because Mercury rotates rapidly
D) 1 1/2 rotations

33b. To what does the phrase "synchronous rotation" for an astronomical object (e.g., planet or moon) refer?
A) It has a rotation rate that is precisely maintained (e.g., 23 h 56 m 4.096 s for Earth).
B) For an object in an elliptical orbit, the rotation rate increases and decreases to match the changes in its orbital speed.
C) It completes precisely one rotation around its own axis for every orbit (1-1 spin-orbit coupling).
D) It has any rotation period that is in simple proportion to its orbital period (1-1 spin-orbit coupling, 3-2 spin-orbit coupling, etc.).

34b. What method first showed that Mercury does not rotate synchronously (one rotation about its own axis for every orbit around the Sun)?
A) Surface temperatures on Mercury's dark side, measured by radio telescopes, were compared to calculated temperatures.
B) individual surface features were monitored visually by Schiaparelli in the 1880s
C) rotational speed was measured by radar from Earth
D) rotation period was measured by direct photography from Mariner 10

35b. The reason the temperature on the dark side of Mercury is warmer than originally expected is that
A) Mercury's large iron core conducts heat through the planet.
B) Mercury does not rotate synchronously with its orbital period.
C) several very active volcanoes on Mercury, produced by tidal stresses from the Sun, produce excess heat.
D) winds in Mercury's tenuous atmosphere carry heat from the daytime side to the night side.

39b. If you are on Mercury and the time is noon (Sun directly overhead), what time of day will it be one Mercurian year later (after Mercury has orbited the Sun once)?
A) noon
B) It could be any time, because Mercury rotates independently of its revolution.
C) midnight
D) just after sunset

43b. Suppose Mercury had 5-to-3 spin-orbit coupling and that its sidereal period remained 88 days, as it is now. What would be the time from noon to noon on Mercury, in days?
A) 88 B) 147 C) 264 D) 440

44b. Suppose Mercury had 5-to-3 spin-orbit coupling and that its sidereal period remained 88 days, as it is now. You observe the Sun directly overhead in the Mercurian sky and then observe again from the same location 88 days later. Where will the Sun be in the sky? (Mercury, like Earth, rotates toward the east.)
A) below the eastern horizon
B) below the western horizon
C) directly overhead again
D) directly on the opposite side of the planet

48b. Which planet most resembles the Moon in visible surface features and atmosphere?
A) Venus B) Mercury C) Mars D) Uranus

54b. What is believed to be the cause of the long, meandering scarps (cliffs) observed on Mercury?
A) shrinkage of the planet as Mercury cooled
B) large impacts near the end of the early period of heavy bombardment
C) volcanic eruptions along crustal faults over hot spots in the mantle
D) crustal movement due to convection in the mantle, similar to continental drift on Earth but to a much smaller extent

79b. Mercury's magnetic field, compared with that of Earth, is

A) of equivalent strength.
B) weak, but strong enough to deflect the solar wind.
C) extremely weak, so it cannot prevent the solar wind from hitting the surface of Mercury.
D) much more powerful.

80b. The magnetic field of Mercury appears to be caused by

A) a solid magnetized iron core.
B) the motion of high-speed solar wind particles around the planet.
C) electric currents in a region of liquid metallic hydrogen in the core.
D) electric currents in a molten iron core.

82b. Two conditions appear to be necessary for the generation of a powerful magnetic field in planets that are not present simultaneously on Mercury. These conditions are

A) rapid rotation and a molten iron core.
B) a molten core and a significant atmosphere.
C) rapid rotation and a conducting atmosphere.
D) a solid surface and a significant iron content.

1c. In Figure 1, which wave has the longest wavelength?

A) A
B) B
C) C
D) D

2c. In Figure 1, which wave has the highest frequency?

A) A
B) B
C) C
D) D

3c. If Mercury were rotating clockwise in Figure 1, how would the waves change?

A) A, B, C, D would have the same wavelength
B) A and C would have the same wavelength
C) A would have a longer wavelength and C would have a shorter wavelength
D) A would have a shorter wavelength and C would have a longer wavelength

4c If Mercury was struck by a asteroid that caused it to suddenly start moving to the right, how would the waves change?

A) A, B, and C would have a decreased wavelength
B) A, B, C, and D would have a decreased wavelength
C) Only B would have a smaller wavelength
D) A, B, and C would have an increased wavelength
E) Only D would have an increased wavelength

5c. If a planet rotates around the Sun in 200 days, what is its orbital period?

A) 100 days
B) 150 days
C) 200 days
D) 400 days

6c. If a planet rotates on its axis with respect to the stars once every 100 days, what is its rotational period?

A) 50 days
B) 100 days
C) 150 days
D) 200days

7c. If the planet shown in Figure 2 has an orbital period of 100 days and a rotational period of 50 days, how long is the length of its day?

A) 50 days
B) 100 days
C) 150 days
D) 200 days

8c If the planet shown in Figure 2 has an orbital period of 100 days and a rotational period of 10000 days, where will the arrow be pointing after 100 days?

A) In almost the same direction as shown

B) to the left
C) straight down
D) straight up

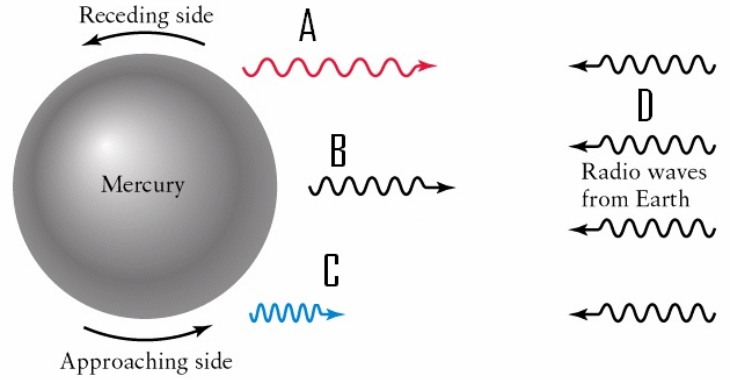

Figure 1

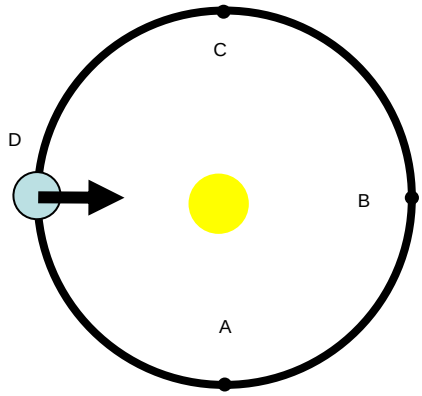

Figure 2. The planet shown at D orbits the star in a counterclockwise direction. The planet rotates on its axis in a counterclockwise direction.

Chapter 12 (Lecture 19) Review Questions

Keywords: equilibrium resurfacing hypothesis, global catastrophe hypothesis, prograde rotation, retrograde rotation, runaway greenhouse effect

General Questions: What makes Venus such a brilliant "morning star" or "evening star"? What is strange about the rotation of Venus? In what ways does Venus's atmosphere differ radically from our own? Why do astronomers suspect that there are active volcanoes on Venus? Why is there almost no water on Venus today? Why do astronomers think that water was once very common on Venus? Does Venus have the same kind of active surface geology as the Earth?

Note: The letters following the number indicate where the question is from, i.e., class (c), online quiz (q), or another source (b).

1q. Venus appears to be very bright in our sky at certain times because
(a) the exposed surface of the planet is mostly new lava and is reflecting sunlight effectively.
(b) it is glowing from the heat of its surface, where the temperature is 750 K.
(c) it is covered in reflective clouds and is relatively close to the Sun.

2q. The planet Venus is often referred to as the Earth's twin planet. Which physical property of Venus is similar to that of the Earth?
(a) Its rotation period, or length of the day.
(b) Its diameter.
(c) The chemical composition of its atmosphere and clouds.

3q. How were astronomers first able to measure the rotation period of Venus (i.e., the length of a Venusian day)?
(a) Soviet astronomers measured times of sunrise on Venus using the Venera 9 and 10 landers.
(b) They sent microwaves to Venus from Earth-based radio telescopes and measured the Doppler shifts in the reflected signals.
(c) While mapping the surface of Venus using microwaves from Earth-based radio telescopes, they timed the passage of different features across Venus's disk.
4q. What is distinctive about the rotation of Venus about its axis?
(a) It rotates in an inverse direction to that of most of the planets, and to the orbital revolution direction of the planets.
(b) Its spin axis is almost parallel to the ecliptic plane in which most planets orbit.
(c) It rotates much more rapidly than does the Earth or Mars, completing one rotation in about 10 hours.
5q. What is believed to be the most likely explanation for why Venus rotates backward (retrograde) compared to most of the other planets and compared to its orbital motion?
(a) It was caused by an object somewhat larger than Mars colliding with Venus during the heavy bombardment phase, in the first 100 or 200 million years after the planets formed.
(b) It most likely formed that way, from random motions in the accreting material that gave rise to Venus.
(c) It was caused by interactions between the Sun and Venus's atmosphere. Tidal friction between the atmosphere and the surface slowed Venus's rotation, and then solar-induced winds started Venus rotating in the opposite direction.
6q. Which of the following statements best describes the planet Venus?
(a) Clear, rarified atmosphere, high surface temperature, and light cratering.
(b) A dense, cloudy atmosphere over an ancient, heavily cratered surface.
(c) Perpetual clouds, high surface temperatures, and light cratering.
7q. The extremely high surface temperatures on Venus were first measured using
(a) the shape and peak wavelength of the black-body continuum radiation in the visible spectral range.
(b) microwaves emitted by the planet's surface, to which the dense Venus clouds are transparent.
(c) infrared emission from CO_2 molecules in Venus's dense atmosphere.
9q. The key gas on Venus that is responsible for the greenhouse effect, the buildup of high temperatures in its lower atmosphere, is
(a) CO_2, carbon dioxide.
(b) H_2O, water vapor.
(c)sulfuric acid vapor.
10q. The so-called greenhouse effect, which produces very high temperatures on the surface of Venus, is
(a) the absorption by the CO_2 gas of the planet's atmosphere of infrared radiation emitted by the (b) hot planet surface, which itself is heated by sunlight.
(c) the absorption of solar visible radiation by the CO_2 gas of the Venusian atmosphere, thereby heating this gas.
(d) the trapping of hot gases ejected by continuously active volcanoes under the dense cloud cover.
11q Compared to the Earth's atmosphere, that of Venus has
(a) much lower temperatures (200 K) because of the dense cloud cover, and higher pressure (100 atmospheres).
(b) much higher atmospheric pressure (100 atmospheres) and temperature (750 K).
(c) much higher temperature (750 K) and hence much lower surface pressure (1/100 atmosphere).
12q. The temperature in the atmosphere of Venus decreases smoothly with increasing altitude all the way from the surface (hottest) to the outermost parts of the atmosphere (coolest). What does this observation tell us about the atmosphere of Venus? (Hint: Think about why the temperature in the Earth's atmosphere differs from this.)
(a) Venus has no distinct layers of clouds or aerosols in its atmosphere.
(b) Venus has essentially no ozone in its atmosphere.
(c) Venus has essentially no convection in its atmosphere.
13q. What interesting result do spacecraft measurements show about sulfur on the planet Venus?
(a) Sulfur is continuously being ejected by Venusian volcanoes, covering large areas of the planet with white sulfur dioxide frost and colorful sulfur compounds.
(b) Sulfur and sulfur compounds are essentially absent in the atmosphere of Venus, in contrast to the Earth where significant levels of sulfur are maintained by intermittent volcanic activity.
(c) Sulfur is an important component of Venus's atmosphere, producing sulfuric acid in the clouds and fluorosulfuric acid on the surface.

22q. If Venus had an atmosphere of about the same density as the Earth's and no greenhouse effect, what would be the probability of life existing on its surface?
(a) Hard to say—there is no information on which to base a decision.
(b) Quite high. Because Venus is in the same part of the solar system as the Earth.
(c) Essentially zero.

23q. The reason that Venus has no magnetic field, even though it is similar in size to Earth, and appears to have a molten core, is
(a) that it is much closer to the Sun and the ionized solar wind swirling around the planet cancels any internal magnetic field.
(b) that the molten interior in nonmagnetic, being composed mainly of aluminum and sulfur, not iron, cobalt, and nickel.
(c) that it rotates very slowly, and this rotation is insufficient to drive the internal magnetic dynamo.

27q. The reason why Venus's surface is only lightly cratered appears to be that
(a) the heavy bombardment that cratered our Moon did not reach in as far Venus and Mercury.
(b) the dense atmosphere protected the surface from ever being heavily bombarded by debris from space.
(c) lava flows have covered over most of the early cratering, and there has been little recent cratering.

1b. Which of the planets fits the following description: "a hot solid surface, cloud-shrouded, with a dense CO_2 atmosphere"?
A) Venus B) Mars C) Mercury D) Jupiter

4b. Venus appears to be very bright in our skies at certain times because
A) even though its surface is very dark, it is relatively close to the Sun.
B) it is glowing from the heat of its surface, where the temperature is 750 K.
C) its rocky surface is shiny, like the surface of new volcanic lava.
D) it is relatively close to the Sun, Earth is close to it, and it is covered by very reflective clouds.

7b. Why are there are so few solar transits of Venus across the Sun's face as it revolves in its orbit and passes through inferior conjunction?
A) The orbital plane of Venus is inclined at 3.4° to the ecliptic plane.
B) The synodic period of Venus is very long because of the relative orbits of Earth and Venus.
C) Venus revolves around the Sun in a retrograde direction compared to the other terrestrial planets.
D) Venus rotates on its axis in a retrograde direction compared to the other terrestrial planets.

8b. On the basis of appearance and general properties, which planetary body could be described as Earth's twin?
A) Pluto—similar in size and density, with a large moon and probably life on its surface
B) Venus—about the same mass and diameter, with a dense and cloud-shrouded atmosphere
C) Mars—somewhat smaller but with a similar surface, a thin atmosphere, and clouds
D) the Moon—somewhat smaller but with the same average density and geology, orbiting at the same distance from the Sun but with no atmosphere

15b. Venus rotates in
A) the same direction as Earth but very rapidly (in a few hours).
B) a "lock-in" situation to the Sun, maintaining one side toward the Sun at all times (synchronous rotation).
C) the same direction as Earth but very slowly.
D) the opposite direction to Earth but very slowly.

21b. The length of one solar day (i.e., time between successive sunrises) on Venus is
A) about the same as that on Earth.
B) much longer than that on Earth.
C) much shorter than that on Earth, about an hour.
D) about half as long as that on Earth, about 10 hours.

26b. The component of Venus's atmosphere that is responsible for the greenhouse effect, or excess heating, is
A) H_2SO_4 or sulfuric acid droplets. B) N_2. C) H_2O vapor. D) CO_2.

31b. The main reason for the very high temperature (750 K) on the surface of the planet Venus is thought to be
A) the intense and continuous volcanic action on the surface and the radiation from hot lava.
B) chemical reactions between the constituents of the atmosphere.
C) the continuous bombardment of the surface by meteoroids and solar wind particles.

D) the absorption of visible radiation by the surface and clouds and the trapping of re-radiated infrared radiation by the atmosphere.

32b. The mechanism of the greenhouse effect, which has resulted in very high temperatures on the surface of Venus (and moderate temperatures on Earth), can be described as

A) solar UV and visible radiation heating the planet surface, the infrared emissions of which are then trapped by CO_2 in the atmosphere.

B) solar infrared radiation heating the planet surface, which then emits visible and UV radiation that is trapped by CO_2 in the atmosphere.

C) solar UV and visible radiation entering the clouds and triggering chemical reactions in the CO_2 and sulfur compounds, the released energy then heating the atmosphere.

D) solar UV and visible radiation being absorbed by the CO_2 of the atmosphere, thereby heating it.

34b. Why is the surface of Venus hotter than that of Mercury, even though Mercury is much closer to the Sun?

A) Chemical reactions within the thick clouds and dense atmosphere are continuously supplying heat to the surface.

B) Continuous volcanic activity releases large quantities of hot lava onto the surface.

C) Venus rotates rapidly, thereby ensuring that its entire surface is being heated regularly and uniformly.

D) The thick CO_2 atmosphere prevents re-emission into space of the heat absorbed from sunlight.

36b. The highest temperature in the atmosphere of Venus occurs

A) in the clear atmospheric layers below the cloud level at an altitude of about 30 km.

B) at the height of the thickest clouds, 48–52 km, where infrared absorption is highest.

C) at the cloud tops, which are heated by sunlight.

D) at the planet's surface.

60b. Which particular chemical associated with volcanic emissions has been detected by various techniques in amounts that appear to vary significantly over short time scales, indicating the presence of active volcanoes on Venus at the present time?

A) carbon in CO_2 and CO

C) silicon and silicate dusts

B) ammonia and methane gases

D) sulfur and sulfur compounds

63b. Hot-spot volcanism is a process that

A) produces gigantic volcanoes on Venus and Mars but produces chains of smaller volcanoes on Earth (e.g., the Hawaiian Islands).

B) produces dome-shaped rises on Venus and Mars and mid-ocean ridges on Earth (e.g., the Mid-Atlantic Ridge).

C) does not operate on Venus or Mars but produces subduction zones on Earth (e.g., along the west coast of North and South America).

D) produces large rift valleys on Mars, Venus, and Earth (e.g., the Great Rift Valley of Africa).

80b. On both Earth and Venus some sulfur dioxide is removed from the atmosphere to be locked up in various rocks and minerals. On Earth this SO_2 is recycled deep beneath the surface to be outgassed by volcanoes and again become part of the atmosphere. On Venus this SO_2 is not recycled. Why this difference?

A) There are no active volcanoes on Venus.

B) Venus does not experience the movement of tectonic plates.

C) On Venus, the sulfur dioxide minerals are dissolved by acids in the atmosphere.

D) Because of the higher temperature on Venus, the SO_2 minerals formed there are different from those on Earth, and they are essentially permanent and nonrecyclable.

81b. At what point did the greenhouse effect cease to raise the temperature of Venus?

A) when all the greenhouse gases evaporated

B) when the radiation from Venus balanced the radiation absorbed by Venus

C) when the CO_2 was dissolved in the early Venusian oceans

D) when the greenhouse gases combined with other chemicals

90b. Tectonic activity on Venus differs from that on Earth in that

A) active crustal deformation appears to be completely absent.

B) the lithosphere appears to be softer or more plastic and cannot support the creation and motion of solid plates.

C) the lithosphere appears to be cooler and thicker and is therefore too rigid to break up into moving plates.

D) mantle convection appears to be more vigorous and has broken the lithosphere into a multitude of small plates instead of a few large ones.

1c. What causes the runaway greenhouse effect on Venus?

(a) Its retrograde motion
(b) Its lack of a way of removing CO_2 from the atmosphere
(c) Its slow rotation which makes the temperature more uniform
(d) Its oceans which contribute H_2O and CO_2 to the atmosphere

2c. Why is the year on Venus longer than that on Mercury?

(a) Venus has retrograde motion
(b) Venus is takes longer to orbit the Sun than Mercury.
(c) Mercury takes longer to orbit the Sun than Venus.
(d) Venus has an atmosphere while Mercury does not.
(e) Venus has an orbital period that is almost the same as its rotational period

3c. Figure 1 is a view of Venus and the Sun from above their north poles. Which way does Venus rotate around the Sun and around its axis?

(a) CCW around Sun, CW around its axis
(b) CW around Sun, CW around its axis
(c) CW around Sun, CCW around it axis
(d) CCW around Sun, CCW around its axis

4c. If an observer says it is noon in Figure 1 at point A, what time is it for the observer at point B?

(a) Noon
(b) Dawn
(c) Dusk
(d) Midnight
(e) 9:00 am

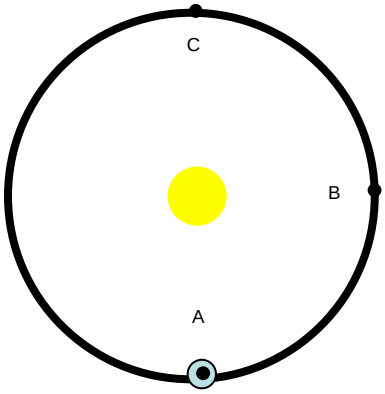

Figure 1: Venus's orbital period is 224 days. Venus's rotation period is 243 days

Chapter 13 (Lecture 20) Review Questions

Keywords: crustal dichotomy, dust devil, favorable opposition, permafrost, residual polar cap, runaway icehouse effect

2q. The length of each of the Martian seasons, compared to those on Earth, is

(a) about the same as Earth because the tilt of Mars's spin axis and rotation rate are similar to those of Earth.
(b) about twice as long because of Mars's orbital period.
(c) about half as long as Earth, due to the relationship between the Martian period of revolution and its synodic period.

3q. What evidence is there for the proposal that at least parts of the Martian surface are very old?

(a) The observations of craters similar to those on our Moon, which were formed at least 3 billion years ago and have survived until the present time.
(b) The observation of polar ice caps on Mars, which probably formed from outgassing water as Mars was being formed, at least 4 billion years ago.

(c) The observation of giant volcanoes which, at the estimated rate of lava flow would have needed at least 2 to 3 billion years to grow to their present size.

4q. Which of the following descriptions best characterizes the surface of Mars?

(a) More-or-less uniform surface of lightly rolling hills and few craters, with two large, continent-sized areas raised above the average terrain.

(b) Two distinct hemispheres: volcanoes and volcanic plains in the northern hemisphere and extensive impact cratering in the southern hemisphere.

(c) Two distinct hemispheres: large, lightly cratered asteroid impact basins in the eastern hemisphere and dense cratering with only two small asteroid impact basins in the western hemisphere.

5q. The volcanoes of Mars are

(a) small, extinct now, and in lines across the planet, indicative of plate tectonic action in the past.

(b) massive, extinct, and solitary structures.

(c) active, spewing sulfur and other compounds into the atmosphere continuously, more like geysers than volcanoes.

9q. Which of the following planets or planet-sized objects is most strongly suspected of having abundant water at the present time?

(a) Venus, one piece of evidence being its global cloud cover.

(b) Mars, one piece of evidence being the persistent white polar caps that survive the heat of summer.

(c) Our Moon, one piece of evidence being ancient flow channels on its surface.

10q. Evidence for water stored as permafrost under the Martian surface is shown in

(a) river valleys extending away from obvious impact craters.

(b) haze layers and steam vents seen by orbiting spacecraft near to active volcanoes on Mars.

(c) the darker color of some parts of the surface of Mars.

11q. The average surface conditions near Mars's north and south poles can best be described as

(a) cold, rocky, and very dusty.

(b) hot, dry, desert.

(c) cold and icy.

15q. Which piece of evidence suggests that the Martian North Pole is covered by a layer of water ice in addition to an overlying layer of CO_2 ice?

(a) The blue color of the polar ice cap is characteristic of water ice, not CO_2 ice.

(b) The initial disappearance of the white north polar cap is rapid as summer approaches but this is disappearance rate slows significantly at a certain time.

(c) Small rivulets of running water are seen around the polar cap as summer comes to this region.

18q. One major feature of the Martian "climate" is

(a) totally overcast conditions, with thick sulfuric acid clouds.

(b) major dust storms.

(c) massive thunderstorms and intense lightning.

20q. Ultraviolet radiation from the Sun has played a more important role in Martian surface chemistry than it has on Earth because

(a) the surface rocks are such that they absorb UV radiation more efficiently than do the rocks on Earth.

(b) the Mars atmosphere contains no ozone to absorb this energetic radiation.

(c) the Mars atmosphere contains no "greenhouse" gases to absorb this UV radiation.

2b. Which planet in our solar system fits the following description: "A planet with a large iron core, heavily cratered surface, and no (or almost no) atmosphere"?

A) Earth B) Mars C) Mercury D) Neptune

3b. Which of the planets fits the following description: "a solid, cool surface, with occasional dust clouds and a thin CO_2 atmosphere"?

A) Venus B) Jupiter C) Mars D) Mercury

1b. Which of the planets fits the following description: "A planet with a very hot, solid, cratered surface with no atmosphere"?

A) Venus B) Mars C) Jupiter D) Mercury

6b. During favorable oppositions of Mars, when the planet comes relatively close to Earth, where would Mars be seen in the sky by an observer in the Earth's northern hemisphere?

A) high in the south at midnight

C) on the western horizon at midnight

B) high in the north at midnight

D) high in the south at sunset

8b. Mars is best viewed from Earth when it is at opposition, but some occasions are more favorable than others. Why is this?

A) Mars has an elliptical orbit, and favorable oppositions occur when Mars is at perihelion in its orbit and hence closest to Earth.

B) Mars has an elliptical orbit, and favorable oppositions occur when Mars is at aphelion in its orbit and hence closest to Earth.

C) Mars's orbit is inclined at a significant angle to the ecliptic, so favorable oppositions occur when it is crossing the ecliptic plane while at opposition.

D) Even though Mars moves in a circular orbit, the orbit of Earth is elliptical and so favorable oppositions occur when Earth is at perihelion.

9b. Assume Earth has a circular orbit with a radius of 1 AU. At its most favorable opposition Mars is 0.37 AU from earth, and at its least favorable opposition it is 0.68 AU from Earth. From these data, what do you calculate as the sidereal period of Mars (in years)?

A) 1.0 B) 1.52 C) 1.88 D) 3.55

13b. Prominent but variable ice caps were detected by early observers on which planet?

A) Venus B) Mars C) Jupiter D) Mercury

17b. Mars experiences similar seasonal changes to those on Earth because

A) it has about the same shape of elliptical orbit as that of the Earth, producing similar changes in solar radiation intensity as the planet orbits the Sun.

B) its spin axis is tilted at about the same angle to its orbital plane as is the Earth's axis.

C) the length of its day is very close to an Earth day.

D) the length of its year is very close to that of Earth.

18b. The equator of Mars is tilted with respect to its orbital plane and therefore Mars

A) shows similar seasons to those on Earth, each season lasting about three months.

B) experiences very long (20 years) seasonal variations.

C) shows no seasonal variation at all.

D) shows similar seasons to Earth, each season lasting about twice the length of seasons on Earth.

39b. The most important mechanism that transports heat outward from the interiors of Venus and Mars is

A) asteroid impact, which splits the crust and allows the heat to escape.

B) rifting and subduction, where rigid plates are pushed around by magma rising up from the mantle.

C) thermal conduction, where heat is conducted outward through the crust with relatively little flow of lava.

D) hot-spot volcanism, where molten lava flows upward to the surface above hot-spots in the mantle.

40b. Hot-spot volcanism is a process that

A) produces dome-shaped rises on Venus and Mars and mid-ocean ridges on Earth.

B) does not operate on Venus or Mars but produces subduction zones on Earth.

C) produces large rift valleys on Mars, Venus, and the Earth.

D) produces gigantic volcanoes on Venus and Mars but produces chains of smaller volcanoes on the Earth.

55b. On the basis of the surface and atmospheric conditions existing on Mars today, why could there be no liquid water on its surface?

A) The water would boil and evaporate rapidly under the low atmospheric pressure or freeze to ice at the low surface temperatures.

B) It would have reacted chemically with the surface rocks.

C) The UV radiation from the Sun would have dissociated the water molecules into hydrogen (which would leave the planet) and oxygen, which is still present.

D) It would have soaked into the porous surface of Mars.

57b. Water exists on Mars. Where and in what state does it NOT exist on this planet?

A) as liquid, flowing in river valleys

B) in permafrost, below the surface

C) in polar icecaps

D) as water vapor in the atmosphere and as clouds

64b. The polar caps on Mars are most likely made up of

A) water and CO_2 ices.

B) light-colored dust blown there by intense dust storms and large dust devils.

C) volcanic outflow of light-colored lava and dust similar to that produced by Earth-based volcanoes.

D) sulfur dioxide and sulfur compounds.

66b. The initial and very rapid recession of the edge of the white polar cap region toward the poles in springtime is caused by
A) the melting and evaporation of CO_2 ice.
B) the increased growth of vegetation toward the poles from mid-latitudes.
C) the change in color of the rocks by photochemical action, similar to bleaching.
D) the melting of H_2O ice and subsequent runoff of water.
69b. A major feature of the atmosphere of Mars is
A) occasional strong winds and dust storms.
B) very dense clouds shrouding most of the planet.
C) a chemical mixture very similar to that of Earth.
D) very high temperatures and pressures.
77b. The carbon dioxide atmosphere of Mars was much denser in Mars's early history than it is now. What process is now believed to have begun this atmospheric thinning?
A) The solar wind stripped the outer atmosphere from the planet.
B) The light CO_2 molecules escaped directly into space because of the weak gravity of Mars.
C) The CO_2 molecules were broken down by solar UV photons, creating the lighter molecules, CO and O_2, which then escaped into space.
D) The CO_2 was washed out of the atmosphere by rain.
76b. The greenhouse effect, which heats a planet's surface above the predicted equilibrium surface temperature for the planet without an atmosphere, is far less effective on Mars than on the Earth. Why is this?
A) The Martian surface temperature is very low, and this reduces the effectiveness of the greenhouse effect.
B) There is less energy being conducted upward from the Martian interior to the surface of Mars because of the thickness of its crust compared to that of Earth.
C) The Martian atmosphere contains no gases that can absorb solar radiation.
D) The Martian atmosphere is very thin and traps less infrared radiation from the surface.
108b. On Mars, which of the following features have NOT been seen or detected?
A) dust storms and dust devils
B) advancing and receding polar icecaps
C) thin, wispy clouds
D) active volcanoes
120b. The moons of Mars are
A) spherical and quite large, compared to the planet; about 1000 km in diameter, similar to the largest asteroid.
B) irregular but quite large, compared to the planet, between 500 and 1500 km across.
C) irregular in shape and very small, only several tens of kilometers across.
D) almost spherical but very small, between 10 and 30 km in diameter.

Chapter 14 (Lecture 21 & 22) Review Questions

Keywords: liquid metallic hydrogen, noble gases, nonthermal radiation, thermal radiation, oblate, oblateness, plasma, synchrotron radiation, tidal force

2q. Jupiter is the largest planet in our solar system. What is Jupiter's mass, compared to that of the rest of the planets?
(a) Jupiter's mass is slightly less than eight times the mass of all the other planets combined.
(b) Jupiter's mass is a slightly more than two times the mass of all of the other planets combined.
(c) Jupiter's mass is almost as much as the mass of all of the other planets combined.
3q. It is advantageous to observe Jupiter when it is at a position of opposition in its orbital motion because
(a) it is closest to the Sun at this position.
(b) it is closest to the Earth at this position.
(c) it appears highest in our sky in the convenient early evening hours at this position.
4q. The Great Red Spot on Jupiter is
(a) a vortex at the north pole of the planet, a cooler region caused by the rapid rotation of the planet.
(b) a large, long-lived anticyclone storm that is maintained by the planet's differential rotation.
(c) clouds of dark gas that have formed above a large volcanic mountain on the planet.

5q. One interesting feature of the motions of the giant planets that distinguishes them from the terrestrial planets is the fact that
(a) they rotate rapidly.
(b) their orbital planes are strongly inclined to the Earth's orbital or ecliptic plane.
(c) they orbit the Sun in a retrograde direction, compared to the terrestrial planets.
6q. How does the visual appearance of Saturn compare to that of Jupiter, excluding the differences in the rings?
(a) Jupiter has an extensive and intricate cloud system of belts, zones, storms, and eddies, whereas Saturn's features appear very subdued and hazy.
(b) Both planets show an extensive system of belts and zones; but on Jupiter very high wind speeds break the zone boundaries into turbulent eddies, whereas on Saturn the winds are slower and very smooth.
(c) Jupiter has an extensive cloud system of large-scale belts and zones, whereas Saturn shows a small-scale system of storms and eddies with a very intricate structure.
7q. The rotation period of the giant planet Jupiter is
(a) very short, about 1 hour.
(b) relatively short, about 10 hours.
(c) much longer than the Earth, about 28 days.
15q. What is believed to be the most important source for the internal heat that Saturn radiates to space?
(a) Raindrops of liquid helium.
(b) The original heat of formation of the planet.
(c) Decay of radioactive elements in Saturn's large, rocky core.
17q. Why do the dark-colored belts on Jupiter appear to be brighter than surrounding regions when observed in infrared or heat radiation?
(a) Because the chemical reactions causing the dark colors are also releasing excess heat in these cloud-tops.
(b) Because these regions are higher in the Jupiter atmosphere, receive more sunlight and hence are hotter.
(c) Because these are relatively cloud-free regions and we are seeing deeper and hence warmer layers of Jupiter's atmosphere.
18q. How does the heat radiated into space by Jupiter compare to the amount received from the Sun, and why?
(a) Jupiter radiates no heat at all into space because it is so far from the Sun.
(b) Jupiter radiates exactly the same amount of heat into space as it receives from the Sun because this is a requirement for equilibrium.
(c) Jupiter radiates twice as much heat into space as it receives from the Sun because it is still cooling down after the process of planetary formation.
19q. Why are the colors and patterns in Saturn's atmosphere more muted and harder to see than those in Jupiter's atmosphere?
(a) Saturn does not have the rapid rotation necessary to produce cloud patterns such as those of Jupiter.
(b) Saturn has a thicker layer of haze above its cloud-tops than does Jupiter.
(c) Saturn is a smaller planet and has a thinner, more transparent cloud layer than does Jupiter.
22q. The cause of the slightly flattened or oblate shape of Jupiter is
(a) the gravitational pull of the Sun and of the other planets.
(b) the cloud cover because higher clouds form around the equator.
(c) its rapid rotation.
26q. What is the cause of the immense magnetic field of Jupiter and Saturn?
(a) Electric currents in the belts and zones of Jupiter's atmosphere.
(b) Electric currents outside Jupiter's core, deep below the atmosphere.
(c) Electric currents in Jupiter's molten core.
27q. What is synchrotron radiation?
(a) High-energy charged particles trapped in planetary magnetic fields.
(b) Electromagnetic radiation emitted by charged particles moving in magnetic fields.
(c) Electromagnetic radiation emitted by any object because of the temperature of the object.
28q. The shape and dimensions of the magnetosphere surrounding Jupiter are controlled by
(a) the outward motion of Jupiter's outer atmosphere against the planet's powerful gravitational field.
(b) the pressure of the solar wind against the extended atmosphere of Jupiter.
(c) the pressure of the ionized gas of the solar wind against the planet's magnetic field.
30q. The rings of Saturn are in which plane around the planet?

(a) Saturn's orbital plane, which is very close to the ecliptic plane.
(b) The plane perpendicular to Saturn's magnetic axis.
(c) Saturn's equatorial plane.

31q. Why do the rings of Saturn appear from the Earth to vary from being very distinct to being almost invisible over a period of a few years?

(a) The Earth is much closer to Saturn at opposition than at conjunction, making the rings more easily seen at opposition.
(b) The ring structure is very thin and is tilted to the ecliptic plane, making it appear almost edge-on and hence indistinct at certain points in Saturn's orbit.
(c) The ice particles of which the rings are composed melt when the planet is closest to the Sun and refreeze when the planet recedes form the Sun.

35q. At distances inside the Roche limit of a planet,

(a) the radiation intensity of radiation emitted from the planet is greater than that from the Sun.
(b) differential tidal forces between particles will overcome mutual gravitational attraction.
(c) the magnetic field of the planet is sufficiently strong to repulse the solar wind.

36q. Saturn's rings are composed of

(a) myriads of icy particles, ranging from dust grains to boulders, moving in Keplerian orbits in the planet's equatorial plane.
(b) a thin dust cloud of minute grains of dust being held above the planet's equator by electrostatic forces and scattering sunlight.
(c) a thin sheet of ionized plasma, held in place within the planet's magnetosphere by the intense magnetic field and reflecting sunlight from its surface.

37q. Why is it that the icy rocks and particles in the rings of Saturn do not coalesce into larger objects and moons under their mutual self-gravity?

(a) Because individual particles in Keplerian orbits are always moving with respect to one another and hence they cannot combine into larger bodies.
(b) Because differential tidal forces from the planet overcomes the gravitational attraction at the ring position.
(c) Because sunlight is continuously melting ice holding particles together, allowing them to separate into smaller particles.

1b. The mass of Jupiter is 11.25 times that of Earth. What would be the force of gravity exerted by Jupiter on a spacecraft at a distance of 1 AU from Jupiter compared to that exerted on the same spacecraft by Earth at 1 AU from Earth?

A) (11.25)2 or 126.25 times as large
C) 11.25 times as large
B) 1/11.25 as large
D) the same magnitude of force

4b. The low average density of Jupiter (about 1300 kg/m3 compared with that of water, 1000 kg/m3) indicates that this planet is composed mainly of

A) hydrogen, in liquid or gaseous form.
B) helium as gas and liquid only, because low temperatures and great pressures are needed to form solid helium.
C) water, compressed somewhat by gravity, maybe in the form of ice.
D) methane, ammonia, and water, from spectroscopic observation of its atmosphere.

5b. When viewed from Earth, the apparent angular diameter of Jupiter varies with time because

A) the distance between Jupiter and Earth varies.
B) of tidal influence of the four massive moons of Jupiter.
C) the fluid planet pulsates with a long natural oscillation period.
D) Jupiter's gaseous atmosphere expands and contracts as the strength of sunlight varies because of the planet's elliptical orbit.

9b. What is the physical appearance of Jupiter as seen from Earth or a spacecraft?

A) a series of dark belts and light zones parallel to the equator
B) a uniform bluish color with a high-level haze
C) v-shaped cloud forms around the equator, indicative of rapid winds
D) uniform red-colored dust clouds over cratered surface

12b. One distinctive feature that is visible on the "surface" of Jupiter through a telescope from Earth is

A) the Cassini Division.
C) Olympus Mons.

B) Maxwell Montes.
D) the Great Red Spot.

14b. The lifetime of the Great Red Spot appears to be

A) similar to that of a sunspot that it resembles—about 2 to 4 weeks between successive appearances.
B) one Jupiter orbital period—about 12 years between successive appearances, because the spot is produced by tidal effects from interaction with other planets.
C) at least 300 years, from visual records.
D) well over 2000 years, from ancient Greek records.

20b. For someone standing on the surface of Jupiter, tomorrow's weather forecast is

A) sunny, possible thin, high clouds.
B) sunny and clear, because Jupiter has no atmosphere in which clouds can form.
C) overcast, possible rain with snow at higher elevations.
D) The question is meaningless, because there is no solid surface on which to stand.

21b. Evidence of volcanism (lava outflow, etc.), either active or ancient, is NOT found on

A) Venus. B) Mars. C) Earth. D) Jupiter.

23b. The rotation periods of Jupiter and Saturn are

A) very short—on the order of 1 hour.
B) very long—several weeks because of their great size and mass.
C) long—on the order of several days.
D) relatively short—on the order of 10 hours.

26b. The interesting feature of Jupiter's rotation is that

A) it rotates in a direction opposite to that of most of the planets and opposite to its direction of revolution around the Sun.
B) its rotation rate has slowed down significantly since it was first observed through telescopes in the 1600s.
C) regions at different latitudes appear to rotate at different rates.
D) its axis of rotation lies almost in the plane of its orbit.

32b. Saturn is less massive than Jupiter but has almost the same size. Why is this?

A) Saturn's interior is hotter than that of Jupiter.
B) Saturn is composed of lighter material than is Jupiter.
C) Saturn is rotating faster than Jupiter, and the increased centrifugal force results in a larger size.
D) The smaller mass exerts less gravitational force and is unable to compress the mass as much as in Jupiter.

33b. How does the composition of Saturn's atmosphere compare to that of Jupiter, which is the same as that of the Sun?

A) Saturn's atmosphere contains less helium than does that of either Jupiter or the Sun.
B) They are almost equivalent, with the same proportions of hydrogen, helium, and heavier elements.
C) Saturn's atmosphere contains far more heavy elements than does that of either Jupiter or the Sun.
D) Saturn's atmosphere has far less hydrogen than does that of either Jupiter or the Sun.

34b. Which is the least dense planet in the solar system?

A) Uranus B) Pluto C) Saturn D) Jupiter

55b. The source of excess heat emitted by Jupiter, above that which is absorbed as sunlight and reemitted, is thought to be

A) heat generated in the interior by the same electrical currents that generate the planet's magnetic field.
B) heat caused by friction between oppositely directed winds at mid-latitudes.
C) gravitational potential energy released as heat during its formation stages, still being released.
D) chemical reactions between methane, ammonia, and water in the planet's atmosphere and clouds.

61b. Saturn's atmosphere does not show the same colorful contrast that we see in Jupiter's atmosphere. This is because

A) Saturn's clouds and circulation pattern resemble those of Earth (individual cyclones and anticyclones) rather than those of Jupiter.
B) Saturn's features are obscured by an upper cloud deck of methane ice crystals, whereas Jupiter has too high a temperature for methane ice.
C) Saturn has a similar circulation pattern to Jupiter, but it is obscured by a much deeper atmosphere.
D) Saturn has counterflowing eastward and westward winds like Jupiter but lacks the three differently colored cloud levels.

63b. One observational fact that is common to both Jupiter and Saturn is that

A) both planets appear cooler than is expected on the basis of received solar energy and emit less radiant energy than expected.
B) the temperature appears to fall continuously as depth into these planets increases, leading to the conclusion that the interiors of these planets are probably extremely cold.
C) CO_2 in their atmospheres appears to produce an intense greenhouse effect with very enhanced atmospheric temperatures of greater than 200°C in the outer layers.
D) both planets emit more energy (in the form of infrared radiation) than they receive from the Sun.

64b. Saturn appears to emit heat as infrared radiation in excess of the energy absorbed from sunlight. The most likely major cause of this heating is
A) condensation of helium into droplets that fall into the planet, releasing gravitational energy as heat.
B) the radioactive decay of naturally occurring isotopes in the atmosphere and interior of Saturn.
C) energy released from the continuous shrinking and condensation of this fluid planet.
D) remnant heat from the original formation of the planet.

70b. Oblateness is a measure of the
A) nonspherical shape of a planet, with the polar diameter being shorter than the equatorial diameter.
B) nonspherical shape of a planet, with the polar diameter being longer than the equatorial diameter.
C) inclination of the orbit of a planet or a moon to the ecliptic plane.
D) noncircular shape of a planet's orbit.

71b. The reason for the slightly flattened or oblate shape of Jupiter is
A) its rapid rotation rate.
B) its cloud cover, more clouds forming over the equator on average.
C) that it was formed that way in the beginning and has maintained this shape.
D) the gravitational pull of the Sun and the other planets in the ecliptic.

75b. The deepest central cores of the interiors of Jupiter and Saturn are thought to be composed of
A) methane, ammonia, and water vapor.
C) magnetized iron.
B) liquid metallic hydrogen.
D) rock.

83b. The material in the interiors of Jupiter and Saturn thought to be responsible for their powerful magnetic fields is
A) molten iron and nickel.
B) liquid metallic hydrogen.
C) gases of NH_3 (ammonia), CH_4 (methane), H_2O (water vapor).
D) solid magnetic iron.

84b. The requirements for the generation of a powerful magnetic field in a Jovian planet (e.g., Jupiter, Saturn) appear to be
A) liquid "metal" interior and relatively rapid rotation.
B) solid iron core forming a permanent magnet.
C) liquid "metal" core and interior and slow rotation.
D) solid interior throughout the planet and slow rotation.

103b. The shape and dimensions of the magnetosphere surrounding Jupiter are controlled by
A) the outward motion of the atoms of Jupiter's outer atmosphere, as it rotates rapidly within the planet's powerful gravitational field.
B) solar radiation pressure pushing against the planet's outer atmosphere.
C) the pressure of the solar wind against the outer atmosphere of Jupiter.
D) the pressure of the ionized gas of the solar wind against the planet's magnetic field.

105b. On what planet would you not expect to find an aurora?
A) Venus B) Earth C) Jupiter D) Saturn

124b. The particles in Saturn's rings
A) move in circular orbits, with the outer particles moving fastest because they are farthest from the planet.
B) all move as if they are one solid disk.
C) revolve in different directions depending on the distance from the planet.
D) move in circular Keplerian orbits, the inner particles moving fastest.

126b. Which of the following describes the motions of the particles in the rings of Saturn?
A) Each moves in almost circular Keplerian orbit around the planet.
B) They move in zigzag patterns within the ring system because of interaction with the major moons.

C) They move in randomly oriented elliptical orbits and collide frequently with each other.
D) They all move in concert as if they were a solid sheet because of electrostatic interaction.

130b. The particles in Saturn's rings are composed of

A) a mixture of iron and nickel.
B) water ice or rock coated with water ice.
C) ammonia and methane ice, possibly with rocky centers.
D) rocks with the reflectivity of dark asphalt.

132b. The Roche limit around a planet is defined as

A) the distance beyond which the orbital velocity of a body in a Keplerian orbit is greater than the escape velocity and matter is no longer captured by the planet.
B) the distance inside which a solid satellite (e.g., a fragment of rock) will be pulled apart by tidal forces.
C) the outer extent of the magnetic field of the planet, or the magnetospheric boundary.
D) the distance inside which relative tidal forces will overcome the mutual gravitational forces of a group of particles.

133b. The reason why the individual particles within Saturn's rings have not combined together by mutual gravitational attraction to form one or two moons is that

A) the gravitational force from the Sun is sufficient to prevent coalescence.
B) tidal distortion forces from the planet are greater than the mutual gravity between the particles.
C) the excess heating from Saturn has melted the ice on the rocks so that the rocks will no longer stick together.
D) they are moving too fast to stick together even if they bump into one another.

134b. The rings of Saturn are composed of very many small particles because

A) they are made up of ice and ice-coated rocks, which break up easily in sunlight.
B) they are inside the Roche limit of Saturn, where tidal forces are stronger than the mutual gravitational forces between particles.
C) they were formed by the impact of a fast-moving asteroid on a large moon, which broke up into very many pieces.
D) they were spun out of the planet under its rapid rotation over a long period of time.

135b. The reason why boulder-sized moonlets are able to orbit within the Roche limit in Saturn's rings without being destroyed is that

A) billions of years of alternate freezing and thawing as they pass from sunlight into Saturn's shadow and out again has given them an iron-hard crust of ice.
B) the gravitational forces between the different parts of the moonlet are greater than the tidal forces pulling them apart.
C) they are too small for tidal forces to operate on them effectively.
D) the chemical bonds between their atoms and molecules are greater than the tidal forces pulling them apart.

150b. The gravitational effect that confines the particles of the F ring of Saturn to a narrow orbit is

A) the gravitational influence of two small shepherding satellites in orbits adjacent to the ring.
B) major gravitational distortion caused by Jupiter.
C) the pressure of the solar wind on these particles.
D) the gravitational effects of the major moons of Saturn, such as Mimas and Enceladus.

Chapter 15 (Lecture 23) Review Questions

Keywords: aerosol, Galilean satellites, hydrocarbon, Io torus, occultation, polymer, prograde, orbit, retrograde orbit, tidal heating, ultramafic lava

1q. The Galilean satellites of Jupiter were not discovered until after the telescope was invented. What property of telescopes was required in order to make these satellites visible?

(a) Telescopes increase the brightness of objects. (The satellites are too faint to be seen without a telescope.)
(b) Telescopes increase the angular distance between objects. (The satellites are too close to Jupiter to be seen without a telescope.)
(c) Telescopes increase the angular size of objects. (The satellites are too small to be seen without a telescope.)

3q. Which of the following parameters of the inner three Galilean satellites are linked by a simple mathematical relationship?

(a) Orbital speeds: Ganymede's speed is twice that of Europa while Europa's speed is twice that of Io.

(b) Orbital radii: Europa orbits Jupiter at twice the distance of Io's orbit while Ganymede orbits at twice the orbital radius of Europa.
(c) Orbital periods: Io orbits twice for each orbit of Europa while Europa orbits twice for each orbit of Ganymede.

4q. On the basis of the relationship between the orbital periods of Io and Europa, how often would they come close together in their orbital paths?

(a) Once every half-orbit of Io or twice per orbit of Io.
(b) Once every 2 Io orbits.
(c) Once every Io orbit.

7q. The fact that Jupiter's moons rotate on their axes in synchronism with their respective orbital motion, taking the same time to rotate as they do to revolve about the planet, was discovered long before detailed images of the moons were available from spacecraft. How was this first discovered?

(a) Slight variations in moon brightness because of rotation were measured and seen to repeat every orbital period of the moon.
(b) The observed shapes of telescope images of these irregular-shaped moons changed in synchronism with the orbital period.
(c) Doppler shift of spectra taken from either side of the moons provided their speeds of rotation, which agreed with synchronous rotation.

9q. How big are the Galilean satellites of Jupiter, compared to other objects in the solar system?

(a) About the size of the largest asteroids; that is, about half the size of our Moon or smaller.
(b) About the size of Mars or slightly larger; that is, about twice the size of our Moon.
(c) About the size of our Moon, or a bit larger.

13q. The source of heat that drives the volcanic eruptions of sulfur and sulfur compounds on Io, the giant moon of Jupiter, is

(a) an intense flux of solar wind particles, continuously striking Io's surface.
(b) radioactive heating in Io's interior, mainly from sulfur isotopes.
(c) tidal distortion and flexing, caused by gravitational effects from Jupiter and other moons.

16q. One very interesting fact about the lava that is seen to be flowing on Io is that

(a) its temperature is significantly higher than that of lava upon the Earth, indicative of a different chemical composition.
(b) its temperature is found to be in the same range as that of flowing lava upon the Earth, indicating that the lava is very similar to that upon Earth.
(c) its temperature is much lower than that of equivalent lava upon the Earth, indicative of melted ice rather than lava as the flowing material.

21q. What specific features led astronomers to conclude that Europa had undergone geological transformation in relatively recent times?

(a) Most of the craters on its surface show evidence that they were formed by impacts upon a molten surface that has now solidified.
(b) There are volcanic mountains and lava flows all over its surface.
(c) There are very few craters upon its surface.

22q. If the surface of Europa, the Galilean moon of Jupiter, is considered to undergo a form of plate tectonics, what plays the role of the mantle upon which the plates slide around on the planet?

(a) A layer of liquid water.
(b) Semimolten lava, just like Earth.
(c) Molten sulfur.

25q. Titan, the largest satellite of Saturn, is the only planetary satellite to have a dense atmosphere. This atmosphere is thought to be composed mostly of

(a) carbon dioxide, such as in the atmospheres of Mars and Venus.
(b) nitrogen, from the breakup of ammonia by solar UV light.
(c) hydrocarbons, such as ethane and acetylene, produced by sunlight interacting with methane.

26q. The source of the nitrogen atmosphere on Titan is probably
dissociation of ammonia by solar UV radiation, the nitrogen being left behind after the loss of the

(a) lighter hydrogen atoms.
(b) dissociation of methane gas by solar UV radiation and the subsequent loss of the lighter hydrogen atoms.
(c) outgassing from Titan's interior, earlier in its geological history.

2b. The outer three Galilean moons of Jupiter differ from Io, the innermost such moon, by having surfaces of

A) water ice. B) smoothly polished rock. C) carbon dioxide. D) sulfur.

3b. The four giant moons of Jupiter were discovered by

A) the Pioneer spacecraft. B) Galileo. C) Ptolemy. D) Newton.

10b. Which of the following motions is seen to be characteristic of the four Galilean moons of Jupiter?

A) They orbit the planet in a plane carrying them over both the north and south poles of Jupiter.
B) They orbit the planet in the opposite direction to the planet's rotation.
C) They each keep the same face toward the Sun at all times.
D) They each keep the same face toward the planet at all times.

13b. Brightness variations of Jupiter's moons as they orbit the planet indicate that the relation between the spin around their axes and their orbital motions is that the

A) moons do not rotate at all while orbiting the planet.
B) moons' rotation is controlled by the gravitational influence of the Sun, and they always keep one face toward it, producing the observed brightness variations.
C) moons rotate on their axes independently of their orbital motion.
D) moons rotate exactly once per orbital period.

14b. Because of mutual gravitational forces between the moons and the planet, the orbital periods of the three inner Galilean moons of Jupiter are in the ratio

A) 1:2:3. B) 1:10:100. C) 1:1:1—equal orbital periods. D) 1:2:4.

15b. If the orbital period of Io, the innermost Galilean moon of Jupiter, is 1.77 days, what is the rotation period around its own axis?

A) 3.54 days—twice the orbital period
B) 1.77 days
C) 1.18 days—2/3 of the orbital period
D) 5.31 days—three times the orbital period

19b. In describing the observations of the movements of the moons of Jupiter, what is the difference between an occultation and an eclipse?

A) An occultation is the passage of the moon into Jupiter's shadow, whereas an eclipse is the disappearance of the moon behind the planet.
B) There is no difference—these terms both describe the disappearance of the moon behind the planet.
C) An occultation is the passage of the moon in front of the planet, whereas an eclipse is the disappearance of the moon behind the planet.
D) An occultation is the disappearance of the moon behind the planet, whereas an eclipse is the passage of the moon into Jupiter's shadow.

26b. The average densities of the Galilean moons of Jupiter follow which pattern with increasing distance from the planet?

A) Average density is the same for all moons, because they were made from the same material.
B) Average increases with distance from the planet.
C) Averge density shows NO pattern with distance, the highest-density moon being Ganymede, the largest moon.
D) Average density decreases with distance from the planet.

34b. Which satellite of Jupiter is volcanically active?

A) Europa B) Ganymede C) Callisto D) Io

35b. The most geologically active object in the planetary system at the present time is

A) Io, a moon of Jupiter. B) the Earth's Moon. C) the Earth. D) Mars.

39b. One of the most important sources of heat in the interiors of moons that orbit close to giant planets is

A) reflection of sunlight from the planet's surface onto the moons.
B) continuous tidal distortion from other moons and the planet.
C) absorption of thermal radiation from the planet.
D) decay of radioactive elements within the moons.

40b. The heating of the interior of the large Galilean moon Io of Jupiter, in order to produce volcanic activity, is probably caused by

A) its original heat of formation.
B) radioactive elements in its surface.
C) nuclear fission within its interior.
D) tidal distortion by Jupiter and its other moons.

54b. Which of the following are NOT seen on Jupiter's satellite Io?

A) sulfur dioxide frost B) volcanic plumes C) lava flows D) impact craters

55b. Why does the innermost Galilean moon of Jupiter, Io, not show a cratered surface, as expected from the appearance of equivalent-sized objects like our Moon, Mercury, and Mars?
A) The large gravitational force generated by Jupiter has diverted most objects away from Io.
B) The surface is completely covered by an ocean of water, partly frozen into ice, which will obviously not show craters.
C) Volcanic action recoats the surface regularly and continuously.
D) Dust storms triggered by heating from Jupiter have quickly filled in any craters.

58b. What peculiar feature accompanies Io in its orbit around Jupiter?
A) a torus or ring of ionized sulfur, oxygen, atoms, and electrons
B) an auroral storm in the magnetosphere that always keeps pace with Io
C) a comet-like tail of rocks and dust, shining by reflected sunlight
D) a narrow ring of rocks and dust, Jupiter's ring, at about Io's orbital distance

59b. How is the Io plasma torus formed?
A) Io's motion through Jupiter's magnetosphere creates currents of electrons and charged particles in a loop between Io and Jupiter's north and south magnetic poles.
B) Io disturbs Jupiter's magnetosphere, causing magnetospheric charged particles to collect in a ring around Io's orbit.
C) Charged particles from Jupiter's magnetosphere ionize and eject atoms from Io's surface and from its volcanic plumes.
D) Io's volcanic plumes propel neutral atoms into orbit around Jupiter, where they are then ionized by high-energy charged particles in Jupiter's magnetosphere.

66b. Which of the following objects in the solar system has the smoothest surface relative to its radius?
A) Io, the volcanic moon of Jupiter, whose surface is continuously coated with volcanic material
B) Earth, with its oceans and molten interior that both allow readjustment of the surface
C) Mercury, in view of the intense solar radiation that has melted and smoothed the surface
D Europa, a moon of Jupiter coated with water ice

97b. Why do we suspect the existence of some liquid beneath the surface of Callisto?
A) The interior appears to be highly differentiated, suggesting the existence of residual heat from the moon's formation.
B) The moon is close enough to Jupiter (which emits more energy than it receives from the Sun) so that its interior should be warm enough to keep pure water liquid.
C) The tidal churning caused by the pull of Jupiter should keep the interior warm enough to keep pure water liquid.
D) There is evidence of an induced magnetic field caused by Callisto's passage through Jupiter's magnetosphere.

100b. Which of the following satellites of planets in our solar system has a significant, dense atmosphere?
A) Titan, a moon of Saturn
C) Triton, a moon of Neptune
B) the Moon, of Earth
D) Io, a moon of Jupiter

102b. Saturn's moon Titan is different from all other moons of planets because
A) lakes of water with floating icebergs are seen upon its surface.
B) it possesses a thick atmosphere.
C) its orbit carries it directly over both poles of the planet.
D) continuously erupting volcanoes are observed upon it.

107b. In what way was methane, CH4, first discovered on Titan, the giant moon of Saturn?
A) by chemical "sniffers" carried by Voyager 2 when it passed very close to Titan
B) spectroscopically, by noting specific absorptions in reflected sunlight
C) by detecting the light of burning methane spectroscopically, similar to that seen from oil or gas-well flares
D) by noting the formation on its surface of colored "ice," characteristic of methane ice