

Chapter 11 Jupiter

MULTIPLE CHOICE.

1) How does the mass of Jupiter compare with that of the other planets?

- A) It is slightly larger and more massive than Saturn.
- B) It is similar to that of the Earth and Venus.
- C) It is twice as massive as all other planets combined.
- D) It is almost as massive as Saturn.
- E) It is about a tenth the mass of the Sun.

Answer: C

2) How does the density of Jupiter compare to the terrestrials?

- A) It is denser than all the terrestrials combined.
- B) It is denser than the Moon, but less dense than any of the others.
- C) Its density is slightly less than Mercury, but more than Mars.
- D) Its density is about the same as Mars.
- E) Its density is less than any terrestrial, but almost the same as the Sun's.

Answer: E

3) How does the heat Jupiter radiates compare to the energy it receives from the Sun?

- A) They are equal, as you would expect for a highly reflective planet.
- B) Jupiter's dark belts absorb most of the solar radiation, so it is cooler in the infrared.
- C) Jupiter radiates back into space about twice the energy it gets from the Sun.
- D) Jupiter is a brown dwarf, about a hundred times less luminous than the Sun.
- E) Jupiter is a red dwarf, about a tenth the Sun's luminosity.

Answer: C

4) What would Jupiter have needed to have become a star?

- A) more moons
- B) more mass
- C) a slower rotation, like the Sun
- D) a different chemical composition
- E) a higher density

Answer: B

5) What is thought to lie at the center of Jupiter?

- A) a core of liquid metallic hydrogen
- B) a rocky core, not unlike a terrestrial planet
- C) liquid helium under great pressure
- D) a hydrosphere larger than Earth
- E) hydrogen fusing into helium

Answer: B

6) How large is Jupiter's magnetosphere?

- A) It is about as large as the Earth's.
- B) It is so large it extends out to the orbit of Io.
- C) It is a million times the volume of the Earth's, extending beyond the orbit of Saturn.
- D) It extends inward to the orbit of Mars.
- E) It envelopes even the Sun and rest of the solar system.

Answer: C

7) What is thought to be the cause of Io's volcanos?

- A) Jupiter's magnetosphere and its charged particles
- B) Jupiter's gravity and the heat it creates

- C) tidal stresses from both Jupiter and Europa
- D) solar radiation focused by Jupiter's gravity
- E) radioactive decay in Io's interior

Answer: C

- 8) What is the origin of the jovian moons?
- A) They all formed with the planet.
 - B) They were main belt asteroids, captured by Jupiter's strong gravity.
 - C) They are Trojan asteroids, orbiting 60 degrees ahead or behind Jupiter.
 - D) The four Galilean moons formed with Jupiter, most others were later captures.
 - E) They were ripped from the planet's interior in an early cataclysmic event.

Answer: D

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

- 1) Describe the seasons of Jupiter.

Answer: Like Mercury and Venus, it has none. Its axial tilt of only 5 degrees keeps its equator always facing the Sun.

- 2) What are the two principal components of Jupiter's atmosphere? How do they relate to its density?

Answer: Hydrogen and helium; these light elements, even under high compression, give Jupiter a density only about a quarter that of the Earth.

- 3) Contrast the internal structure of a planet like Jupiter with that of a typical terrestrial planet in as many ways as possible.

Answer: Jupiter's structure as one moves toward the center is increasing density of hydrogen with some helium, eventually turning liquid, then metallic, with a rocky core at the center. Terrestrial planets are rocky, growing molten as you go down, with a core of iron. The iron core is molten on the outside and solid in the center.

- 4) What material makes up most of Jupiter's volume, and why is it not found here?

Answer: Liquid metallic hydrogen can be formed only under tremendous pressure, not found even in the Earth's interior, much less on its surface.

- 5) Contrast the internal structures of the four Galilean moons. How are their internal differences reflected in the nature of their surfaces and other factors like their mean densities?

Answer: Io: Molten to core, high density (3600 kg/m³), abundance of sulfur. Surface very active.

Europa: Water ice crust over liquid water ocean over rocky core. Lower density than Io (3000 kg/m³).

Surface somewhat active, with only a few fairly new impact craters.

Ganymede, Callisto: Water ice, frozen. Low density (1900 kg/m³). Surface dead and inactive, with many craters.

Chapter 12 Saturn

MULTIPLE CHOICE.

- 1) Our knowledge of which of the following has changed most in the last decade?

- A) masses of the jovian planets
- B) number of the jovian planets
- C) density of the jovian planets
- D) rotational periods of the jovian planets
- E) number of satellites of the jovian planets

Answer: E

- 2) The atmosphere of Saturn is composed mostly of:

- A) methane and ammonia.
- B) carbon dioxide and ethane.
- C) hydrogen and helium.
- D) hydrogen sulfide and ammonia.
- E) nitrogen and oxygen.

Answer: C

- 3) Why does Saturn radiate even more excess energy than Jupiter?
- A) Saturn is still radiating heat left over from its formation.
 - B) Saturn's thick cloud layer contributes to a larger greenhouse effect.
 - C) Helium rain gives off heat as it differentiates toward Saturn's center.
 - D) Saturn's atmosphere contains much methane, creating a large Greenhouse effect.
 - E) Saturn can fuse hydrogen into helium in its core, like the Sun.

Answer: C

- 4) What are Saturn's rings?
- A) a great disk of liquid helium
 - B) large rocky boulders moving in orbit around Saturn
 - C) a glowing, flat magnetospheric auroral display
 - D) a solid thin disc of material encircling Saturn
 - E) small icy particles moving in orbit around Saturn

Answer: E

- 5) Cassini is:
- A) the French astronomer who first discovered a gap in Saturn's rings.
 - B) a gap in the rings created by a resonance with Mimas.
 - C) NASA's orbiter now taking photos of Saturn.
 - D) all of the above
 - E) none of the above

Answer: D

- 6) Titan is an interesting moon because:
- A) beneath its clouds, Titan may be Earth-like, with liquid water.
 - B) the Huygens rover has sent back images of sedimentary rocks there.
 - C) it has a rich atmosphere that may resemble that of the early Earth.
 - D) it is known to have ice volcanism on its surface.
 - E) all of the above

Answer: C

- 7) The atmosphere of Titan is composed mostly of:
- A) oxygen.
 - B) methane.
 - C) carbon dioxide.
 - D) hydrogen.
 - E) nitrogen.

Answer: E

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

- 1) Contrast the size, mass, and density of the two largest planets.

Answer: Saturn is almost as big as Jupiter in size and volume, but with only a third the mass of Jupiter, is less than half as dense, so low it is less dense than water.

- 2) Compare the weather visible on the disks of the two largest planets.

Answer: Jupiter has much more striking belts and zones; Saturn is farther from the Sun, and generates much less internal heat than more active Jupiter. It also has thicker clouds than Jupiter's.

3) Jupiter and Saturn are the two largest examples of the gas giant planets. In what ways are they similar? In what ways are they different?

Answer: Similarities: Jupiter and Saturn are both large, composed of hydrogen and helium, have metallic hydrogen in the interior, rocky cores, strong magnetic fields, many moons, and radiate excessive heat. Differences: Jupiter is denser and has a much stronger magnetic field. Saturn has a helium deficit.

4) What is a planet's Roche limit?

Answer: The distance from a planet inside which a moon will be tidally torn apart.

5) Explain how shepherd moons constrain the motions of small particles into a narrow ring about a planet.

Answer: A moon tends to push ring particles away from it. Two shepherding moons are then able to push ring particles together into a narrow ring that lies between the orbits of the two moons.

6) Contrast Saturn's moon Titan with Earth's moon.

Answer: Titan and Earth's Moon are similar size and have similar surface gravity. The Moon is denser. Titan is icy, colder, and has a thick atmosphere.

7) In what two ways is Titan's atmosphere like our own? Now name two differences.

Answer: Like the earth's, Titan's atmosphere is made chiefly of nitrogen, and it is at about the same barometric pressure as the earth at both surfaces. However, it is much colder, lacks any substantial oxygen, and its clouds are made of methane and other hydrocarbons, not water droplets like ours.

Chapter 13 Uranus, Neptune, and Pluto

MULTIPLE CHOICE.

1) Which of the following is true about the seasons on Uranus?

- A) The seasons on Uranus are not unlike those on Earth or Mars.
- B) The uranian rotation axis produces some extreme seasonal effects.
- C) Like Jupiter, Uranus has little tilt, with its equator always facing the Sun.
- D) From the uranian equator, the Sun would remain stationary all the time.
- E) Uranus' weather will become less turbulent as equinox approaches in 2010.

Answer: B

2) The only spacecraft to have visited Uranus and Neptune was:

- A) Pioneer 10.
- B) Pioneer 11.
- C) Voyager 1.
- D) Voyager 2.
- E) Cassini.

Answer: D

3) The outer jovian planets have a bluish tint because:

- A) at their distances, the Sun appears blue, the red absorbed by dust in the ecliptic.
- B) they are far away and distance makes objects appear bluish.
- C) their atmospheres contain methane, which absorbs red light.
- D) their atmospheres contain hydrogen and helium.
- E) ammonia ice reflects blue light better than any other color.

Answer: C

4) Of the jovian planets, which does not have an internal source of heat?

- A) Jupiter
- B) Saturn
- C) Uranus
- D) Neptune
- E) Pluto

Answer: C

5) What is erupting out of the geysers on Triton?

- A) liquid water with basalt
- B) liquid methane with a dark hydrocarbon slush
- C) liquid nitrogen with carbon grit
- D) liquid carbon dioxide with graphite
- E) liquid hydrogen with dark helium ash

Answer: C

6) What could explain the darker appearance of moons and rings in the outer solar system?

- A) They shine by the diminished light at that great distance from the Sun.
- B) They are made of small, sooty particles and radiation darkening with loss of volatile bright ices.
- C) They are composed of basaltic eject from the volcanism on Ariel and Triton.
- D) They are made of water ice that reflects light much more poorly at the very low temperatures of these moons.
- E) They are composed of mostly rocky material, like S type asteroids.

Answer: B

7) Pluto cannot be called a jovian planet because:

- A) it has more helium than hydrogen in its thin atmosphere.
- B) it is more like a terrestrial planet in terms of its density.
- C) it has no rings.
- D) its orbit is not as circular as are the jovians.
- E) in size and mass, it is more like one of their icy moons.

Answer: E

8) The largest Kuiper Belt body is apparently:

- A) Sedna.
- B) Chiron.
- C) Pluto.
- D) Charon.
- E) Triton.

Answer: C

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

1) Explain why the two outermost gas giant planets, Uranus and Neptune, appear so different from the innermost gas giant planets Saturn and Jupiter.

Answer: Uranus and Neptune appear significantly different from Jupiter and Saturn because of the differing amounts of ammonia and methane in their outer atmospheres. The amount of ammonia decreases with distance from the Sun because it freezes out below 70 K. Thus Uranus and Neptune have little gaseous ammonia in their atmospheres. Methane is found in increasing abundance with distance from the Sun and gives a blue color to the planets. Uranus appears bluish-green and Neptune, very blue.

2) Why do Uranus and Neptune appear bluish?

Answer: Their atmospheres contain much methane but not much ammonia. Methane absorbs red light. Ammonia ice accounts for the bright white zones of Jupiter and Saturn. Apparently it is in solution with water in an ice-slush mantle for both.

3) Describe the general internal structure of a terrestrial and the inner and outer jovian planets. What

factors are primarily responsible for the differences in their structures?

Answer: Terrestrial: Central iron core, surrounded by rocky mantle, surrounded by thin crust.

Inner Jovian: Central ultra-dense rocky core, surrounded by hydrogen and helium (hydrogen is metallic for Jupiter and Saturn), surrounded by thick atmosphere with heavy clouds in multiple layers.

Outer Jovian: For Uranus and Neptune, Ammonia-water ice slush replaces the liquid metallic hydrogen for their mantle.

In all cases, the major determining factor is the mass of the planet: Large masses will naturally evolve into jovians. It is believed that jovians can only form far from the central star, where the temperatures are low enough to allow hydrogen and helium to be retained.

4) What will happen to Triton in the distant future, based on its present orbit?

Answer: Due to its retrograde orbit, it will spiral into Neptune and be torn apart into a ring when it reaches Neptune's Roche Limit. Its tidal forces will probably also heat up Neptune still more; it is already warmer than Uranus.

5) Contrast (similarities and differences) the ring systems that surround the four outer planets. Also note how each system was originally discovered.

Answer: The rings of Saturn and Uranus were found from Earth; the bright ones of Saturn by Huygens in 1659, the dark ones of Uranus in 1977. Only Saturn's rings are bright. Uranus' and Neptune's rings are mostly very narrow. Neptune's rings have a clumped structure. Jupiter's and Neptune's rings were found by Voyagers; Jupiter's by Voyager 1 in 1979, Neptune's by Voyager 2 in 1989. Uranus' ring was found during a stellar occultation; Neptune's were suspected from occultation, but had to be confirmed by Voyager 2.

6) Name two reasons to keep Pluto as the ninth planet. Now name two reasons to reclassify it.

Answer: It has a moon, an atmosphere when near perihelion at least, it is larger than any of the asteroids, and tradition. Its orbit is out of the ecliptic, cuts inside Neptune's orbit, and more eccentricity than most asteroid orbits; it is also smaller than any terrestrial and many moons, and probably a lot more like the Kuiper Belt bodies than any planet; some of the Kuiper Belt bodies even have orbits in 3:2 resonance with Neptune like Pluto's orbit; they are even nicknamed the "plutinos".

Chapter 14 Solar System Debris

MULTIPLE CHOICE.

1) The Amor asteroids have orbits that:

- A) stay closer to the Sun, on average, than we do.
- B) stay out beyond Neptune.
- C) stay sixty degrees ahead of or behind Jupiter.
- D) cross the orbit of Mars, but not Earth, at perihelion.
- E) cross the orbit of Earth at perihelion.

Answer: D

2) The orbits of most asteroids:

- A) lie beyond Neptune.
- B) lie entirely beyond the orbit of Mars.
- C) cross the orbit of Mars.
- D) cross the orbit of Earth.
- E) cross the orbits of all four terrestrial planets.

Answer: B

3) What is the typical size of most known asteroids?

- A) a few meters
- B) a few kilometers
- C) a few hundred kilometers

- D) larger than the Moon
 - E) larger than the Earth
- Answer: B

- 4) What is the defining property of the Trojan asteroids?
- A) Their orbital periods are exactly one year, like ours.
 - B) They have orbits that cross the orbit of the Earth, but not that of Venus.
 - C) They have orbits at the distance of Jupiter and 60 degrees ahead of or behind it.
 - D) They have orbits between Saturn and Uranus.
 - E) Like Pluto, they are in a 3:2 resonance with Neptune.
- Answer: C

- 5) The type of asteroid that would appear darkest and reflect the least light is type:
- A) A.
 - B) B.
 - C) C.
 - D) D.
 - E) S.
- Answer: C

- 6) The type of asteroid that would be the densest would be type:
- A) C.
 - B) M.
 - C) S.
 - D) V.
 - E) Z.
- Answer: B

- 7) The three largest asteroids are:
- A) Pluto, Sedna, and Quaoar.
 - B) Deimos, Phobos, and Athos.
 - C) Ida, Gaspra, and Mathilde.
 - D) Ceres, Pallas, and Vesta.
 - E) Halley, Hale-Bopp, and Hyakutake.
- Answer: D

- 8) The nucleus, or main solid body, of a comet has a typical size of:
- A) a few centimeters.
 - B) a few meters.
 - C) a few kilometers.
 - D) a few hundred kilometers.
 - E) a few thousand kilometers.
- Answer: C

- 9) The orbits of most comets:
- A) are like the planets, fairly circular and in the ecliptic plane.
 - B) lie almost entirely beyond the orbit of Neptune.
 - C) have perihelions within the orbits of Mercury.
 - D) go no farther out than Pluto, then return to the sun again.
 - E) are shorter than the 76 year period for Comet Halley.
- Answer: B

- 10) The Oort Cloud is thought to be:
- A) the cloud of gas and dust from which our solar system formed.
 - B) a cloud of debris that occasionally encounters the Earth, causing a meteor shower.

- C) the spherical cloud of comets and some larger icy bodies surrounding the outer solar system.
- D) a cloud of asteroids moving between the orbits of Mars and Jupiter.
- E) the material in the ecliptic plane that creates the zodiacal light.

Answer: C

- 11) The Kuiper Belt objects have orbits that:
- A) carry them thousands of A.U. beyond the Sun.
 - B) stay out just beyond Neptune and close to the ecliptic.
 - C) stay sixty degrees ahead of or behind Jupiter.
 - D) cross the orbit of Mars at perihelion.
 - E) cross the orbit of Earth at perihelion.

Answer: B

- 12) What causes a meteor shower?
- A) The solar wind chills the plasma and causes it to condense into particles.
 - B) Earth intercepts a stray swarm of asteroids left by a collision.
 - C) Earth crosses the orbit of an old comet, whose orbit is littered with debris.
 - D) Earth encounters the asteroid belt when Mars' gravity pushes it toward us.
 - E) A small constellation of dying stars disintegrates.

Answer: C

- 13) The major impact in the Yucatan wiped out the dinosaurs about:
- A) 450 million years ago.
 - B) 200 million years ago.
 - C) 65 million years ago.
 - D) 36 millions years ago.
 - E) less than two million years ago.

Answer: C

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

- 1) There are three classes of asteroids, based on their surface reflectivities. Name them, and describe their composition in terms of the differentiation process.

Answer: Type M are metallic in appearance, probably fragments of the metal rich core of a broken up parent body. Type S are reddish in color with stony composition, typical of mantle material. Type C are very dark with carbon rich crusts that were never very heated.

- 2) There are three types of Earth-approaching asteroids; describe the differences in their orbits in relation to the planets.

Answer: Amor orbits cross the orbit of Mars but not Earth. Apollos cross the orbits of Mars and Earth, some even cutting across the orbits of Venus and Mercury. Aten orbits are on average smaller than the Earth's, and have orbital periods of less than a year; some have aphelions beyond 1 A.U., but not as far out as Mars.

- 3) What is the largest asteroid? The brightest? Why are they not the same?

Answer: Ceres is the largest, and only one that is about spherical. But it is type C, so its dark surface does not reflect as much light as smaller but brighter Vesta.

- 4) What is the Kuiper Belt? What is its most famous member?

Answer: A belt of large, dark, icy bodies, like huge comet nuclei, between 30 and 55 A.U. from the Sun, lying in the ecliptic plane. Pluto was the first of them to be found.

- 5) Contrast the the Oort Cloud and the Kuiper Belt.

Answer: In the Oort Cloud comets have orbits up to 50,000 A.U. from the sun. These comets reach the inner solar system through having their orbits perturbed. We then see the comets as they pass close to the

sun. Sedna is the first body which stays out in the Oort Cloud to be found. By contrast, Kuiper Belt Objects orbit close to the ecliptic plane, and just beyond the orbit of Neptune. Like Pluto, several other KBOs are in a 3:2 orbital resonance with Neptune.

6) Describe the properties of meteoroids.

Answer: Objects of rocky material, from microscopic size up to 100 m across, which orbit the Sun. Most originate from collisions between asteroids or are particles released by comets.

More Essays

1) Imagine that you are holding a meteorite in your hand. Trace back all the events that took place, over the past 4.6 billion years, that led to this meteorite being in your hand. Include the times when these events occurred. Be creative and use your imagination, but keep it founded in astronomy.

2) Discuss how Uranus became tilted into its present position.

Choose whether it happened while forming or at a later date. Which of these is more likely?

3) Imagine that you are in a spacecraft descending through the planet Jupiter. First you move slowly through the atmosphere and then more quickly through the interior. The spacecraft, being indestructible, protects you completely but allows you to observe the environment. Describe what you see and feel.

4) Imagine you have discovered life in the atmosphere of Jupiter. Describe what it is like and how it has adapted to its environment. Please use your imagination but remember, the environment must be consistent with what we know about Jupiter.

5) Explain the conditions that led to these circumstances:

1. Mercury has no moon.
2. Pluto is not a gas giant.
3. Uranus has an extremely tilted orbit.
4. There is no planet between Mars & Jupiter.
5. Meteor showers occur at the same time each year.
6. Comets are mostly ice.
7. The direction of a comet's tail.
8. Jovian planets rotate faster than the terrestrials.
9. Rings are found closer to the planet than moons.

6) Describe each of the planets and their atmospheres in the solar system, indicating a few observable properties with emphasis on the one which distinguishes that object from all others. Answer:

1. Mercury: Small, rocky, no moon, no significant atmosphere, 3:2 spin-orbit resonance.
2. Venus: Rocky, thick carbon dioxide atmosphere, hot, cloud cover, no moon.
3. Earth: Rocky, unique nitrogen-oxygen air, water, life, large moon.
4. Mars: Rocky, red color, two small moons, thin atmosphere of carbon dioxide.
5. Jupiter: Gaseous H and He, largest planet, Great Red Spot, many moons.
6. Saturn: Gaseous H and He, low density, large, rings, many moons.
7. Uranus: Gaseous with more methane, blue-green color, tilted rotation, ring, many moons but no large ones, odd magnetic field, featureless surface.
8. Neptune: Gaseous with more methane, bluish, warmer cloud-tops than Uranus, large moon (Triton) in retrograde orbit.
9. Pluto: Small, eccentric orbit, icy, double planet with moon Charon, thin atmosphere only near perihelion.