Introductory Astronomy

Homework 15: Gas Giant Planets Not to be handed in. Homework solutions are posted already.

---

026 qmult 00110 1 4 2 easy deducto-memory: gas giant planet sizes

1. The gas giant planets in order of decreasing diameter are:

   a) Saturn, Jupiter, Uranus, and Neptune. b) Jupiter, Saturn, Uranus, and Neptune. c) Uranus, Neptune, Jupiter, and Saturn. d) Jupiter, Saturn, Earth, and Venus. e) Ganymede, Callisto, Io, and Europa.

   SUGGESTED ANSWER: (b) See Cox-295. The oblatenesses of Uranus and Neptune are comparable and are only about 2 %: so oblateness is not a complicating factor in deciding the order of Uranus and Neptune.

   Wrong answers:
   a) Everyone knows Jupiter is the biggest planet: the king of the planets.
   d) Earth and Venus are not gas giants.
   e) These are the Galilean moons of Jupiter, but they are in order of decreasing size.

   Redaction: Jeffery, 2001jan01

---

026 qmult 00200 1 1 1 easy memory: gas giant elements

2. The most abundant elements in the gas giants are

   a) hydrogen and helium. b) carbon and nitrogen. c) carbon and helium. d) silicon, oxygen, and iron. e) hydrogen and iron.

   SUGGESTED ANSWER: (a)

   Wrong answers:
   d) This probably true for the rocky planets.

   Redaction: Jeffery, 2001jan01

---

026 qmult 00300 2 1 3 moderate memory: gas giant moon formation

3. The moons of the gas giants probably mainly formed by two processes. One of these is formation from a miniature protoplanetary disk that formed around the gas giant. The other is:

   a) fission of material from the gas giant due to high rotation. The material then coalesced into moons.
   b) by giant impactors that knocked material off the gas giants. The material then coalesced into moons.
   c) gravitational capture of small bodies such as planetesimals, protoplanets, asteroids, icy bodies, and maybe comets.
   d) close encounters with passing stars that pulled material out of the planets. The material then coalesced into moons.
   e) ejection of material from giant volcanoes on the gas giants. The material then coalesced into moons.

   SUGGESTED ANSWER: (c)

   Wrong answers:
   d) A close encounter with another star is probably a pretty rare event and would likely disrupt all the planet orbits.

Redaction: Jeffery, 2001jan01

---

026 qmult 00400 2 4 3 moderate deducto-memory: liquid metallic hydrogen

4. This substance does **NOT** ordinarily exist on Earth, but likely is a major component of Jupiter and Saturn and perhaps all the gas giants.

   a) Molecular hydrogen gas. b) Helium gas. c) Liquid metallic hydrogen. d) Solid metallic hydrogen. e) Methane gas.

   SUGGESTED ANSWER: (c) In the late 1990's liquid metallic hydrogen was created in the lab. Pressures of more than about 1 million atmospheres were required (HI-207). But before that liquid metallic hydrogen had been theorized to exist in gas giant planet interiors.

   Wrong answers:
   a) It's not a significant component of the atmosphere, but its not an uncommon substance: we make easily and I think there are natural sources too: mines and mineral oil deposits?
   b) It is a minor atmospheric component.
   d) I don't know if solid metallic hydrogen can exist even in principle.

   Redaction: Jeffery, 2001jan01

---

026 qmult 00600 1 4 3 easy deducto-memory: rings maintained

5. "Let's play *Jeopardy*! For $100, the answer is: These orbiting structures are maintained around planets because the planet tidal force is too strong to allow them to coalesce under their self gravity into moons."

   What are _____, Alex?

   a) planets b) comets c) rings d) toroids e) clumps

   SUGGESTED ANSWER: (c)

   Wrong answers:
   d) Jupiter does have toroid of particles called the halo. But that feature is so far unique.

   Redaction: Jeffery, 2001jan01

---

026 qmult 00700 2 4 1 moderate deducto-memory: ring flatness

6. Why are the ring systems of the gas giants flat?

   a) There is a **COLLISIONAL PROCESS** that eventually causes the ring particles to orbit in a disk and the alignment of the disk favored by the gravity of the oblate planet is alignment with the planet's **EQUATORIAL PLANE**.
   b) There is a **COLLISIONAL PROCESS** that eventually causes the ring particles to orbit in a disk and the alignment of the disk favored by the gravity of the oblate planet is alignment with the planet's **POLAR PLANE**.
   c) There is a **MAGNETIC PROCESS** that eventually causes the ring particles to orbit in a disk and the alignment of the disk favored by the gravity of the oblate planet is alignment with the planet's **EQUATORIAL PLANE**.
   d) There is a **MAGNETIC PROCESS** that eventually causes the ring particles to orbit in a disk and the alignment of the disk favored by the gravity of the oblate planet is alignment with the planet's **POLAR PLANE**.
   e) The tenth planet from the Sun, Planet X, gravitationally perturbs the rings particles into disk in the planet's **POLAR PLANE**.

   SUGGESTED ANSWER: (a) See web sources. And if its on the web it must be true.

Wrong answers:

b) The polar axis of a planet is a line and so cannot define a unique plane: infinitely many planes can be drawn through a line.

Redaction: Jeffery, 2001jan01

---

027 qmult 00100 1 1 1 easy memory: Jupiter's order number

7. Jupiter is:

a) the fifth planet from the Sun. b) the fourth planet from the Sun. c) the sixth planet from the Sun. d) a comet. e) the tenth planet from the Sun. It has often been called Planet X.

SUGGESTED ANSWER: (a)

Wrong answers:

b) That's Mars.
c) That's Saturn.
d) Come on.
e) Planet X is the conjectured 10th planet. People have looked for it for decades and tried to calculate it's position, but if it exists, it's remained elusive.

Redaction: Jeffery, 2001jan01

---

027 qmult 00300 1 1 3 easy memory: Jupiter impact craters

8. Jupiter's observable surface is:

a) **uncratered** by impacts because of its extreme **volcanic activity**.
b) **heavily impact cratered** because of its extreme **volcanic activity**.
c) **uncratered** by impacts because it is a **gas**.
d) **uncratered** by impacts because it is **solid**.
e) bright green cheese due to impact cratering.

SUGGESTED ANSWER: (c) Gases and liquids are both fluids.

Wrong answers:

e) Maybe for the Moon this would be plausible.

Redaction: Jeffery, 2001jan01

---

027 qmult 00400 2 4 3 moderate deducto-memory: Jupiter composition

9. Jupiter's composition by mass is estimated to be dominated by:

a) methane (**90** percent) and ammonia (**9** percent).
b) carbon dioxide (**55** percent) and molecular nitrogen (**36** percent).
c) hydrogen in liquid molecular and liquid metallic form (**78** percent) and helium (**19** percent).
d) hydrogen in liquid molecular and metallic form (**19** percent) and helium (**78** percent).
e) methane (**9** percent) and ammonia (**90** percent).

SUGGESTED ANSWER: (c) Seeds gives the fractions in (c) as right. They must be nearly so, but they may not be quite the numbers he gives. But whether they remember the precise numbers or more likely not student should remember H and He dominate, and that hydrogen is most dominant.

Wrong answers:

a) Jupiter does have ammonia clouds (NH_3). There may be methane on Jupiter too.
b) No.
d) Hydrogen more than helium.
e) Same as (a)

Redaction: Jeffery, 2001jan01

---

027 qmult 00500 2 4 3 moderate deducto-memory: Jupiter's colors

10. The source of Jupiter's colors (reds, browns, oranges, etc.):

a) is various forms of hydrogen and helium. b) is iodine. c)'has not yet been determined. The source is probably trace chemicals of sort or another: perhaps organic molecules, sulfur, or phosphorus. d) is iron. e) is vegetation.

SUGGESTED ANSWER: (c)

Wrong answers:
a) molecular hydrogen gas and helium gas are clear.
b) a very trace element, but I can't absolutely affirm it could not have an effect.
d) iron near the surface of Jupiter? but I can't absolutely affirm it could not have an effect.
e) There is be no life that we know of on Jupiter.

Redaction: Jeffery, 2001jan01

---

027 qmult 00700 1 4 2 easy deducto-memory: Jupiter's bands

11. On Jupiter the rising and sinking convective flows at the surface are:

a) organized into bright and dark bands that are **perpendicular** to the equator and meet at the poles.
b) organized into bright and dark bands that are **parallel** to the equator.
c) organized into **granules** and intergranule surroundings as on the Sun.
d) completely undetectable. Their existence is known only from modeling.
e) completely green in color.

SUGGESTED ANSWER: (b) We've talked about convection in band form. From pictures the students know the bands are parallel to the equator.

Wrong answers:
e) As Lurch would say: "Aaaarrh."

Redaction: Jeffery, 2001jan01

---

027 qmult 00800 2 4 2 moderate deducto-memory: Jupiter's bands in detail

12. On Jupiter the rising and sinking convective flows at the surface are:

a) organized into bright and dark bands that are **PERPENDICULAR** to the equator and meet at the poles. The bright bands are the **HOT, HIGH-PRESSURE RISING GAS** and dark bands are **COOLER, LOW-PRESSURE SINKING GAS**. The dark bands are at lower elevation and receive less solar illumination.
b) organized into bright and dark bands that are **PARALLEL** to the equator. The bright bands are the **HOT, HIGH-PRESSURE RISING GAS** and dark bands are **COOLER, LOW-PRESSURE SINKING GAS**. The dark bands are at lower elevation and receive less solar illumination.

c) organized into bright and dark bands that are **PARALLEL** to the equator. The bright bands are the **COOLER, LOW-PRESSURE SINKING GAS** and dark bands are **HOT, HIGH-PRESSURE RISING GAS**. The dark bands are at lower elevation and receive less solar illumination.
d) organized into bright and dark bands that are **PERPENDICULAR** to the equator. The bright bands are the **COOLER, LOW-PRESSURE SINKING GAS** and dark bands are **HOT, HIGH-PRESSURE RISING GAS**. The dark bands are at lower elevation and receive less solar illumination.
e) completely green in color.

SUGGESTED ANSWER: (b) See Se-498. We've talked about convection in band form. From pictures the students know the bands are parallel to the equator.

Wrong answers:
e) As Lurch would say: "Aaaarrh."

Redaction: Jeffery, 2001jan01

---

027 qmult 00900 2 4 4 moderate deducto-memory: Jupiter's radiation
13. Jupiter radiates:

a) about **100 TIMES** the energy it absorbs from the Sun. This energy comes from a cold hydrogen fusion in its center.
b) about **100 TIMES** the energy it absorbs from the Sun. Most of this energy comes from residual formation and radioactive heat stored in its interior.
c) about **2 TIMES** the energy it absorbs from the Sun. Most of this energy comes from formation heat and radioactive heat stored in its interior. The emitted radiation heats **Io,** and thus causes Io's extensive **VOLCANIC ACTIVITY**.
d) about **2 TIMES** the energy it absorbs from the Sun. Most of this energy comes from residual formation and radioactive heat stored in its interior.
e) about **4 TIMES** the energy it absorbs from the Sun. Most of this energy comes from formation heat and radioactive stored in its interior. The emitted radiation heats **Io,** and thus causes Io's extensive **VOLCANIC ACTIVITY**.

SUGGESTED ANSWER: (d) See Se-495, FMW-216, SRJ-211, Lewis132. Note it's twice the energy absorbed from the Sun. We don't count reflected energy according to Lewis132 and FMW-216 in conjunction. Jupiter's albedo is .52 (Ab-14-3), .51 (Se-495), .44 (optical/IR) (Lewis131).

Wrong answers:
a) Cold fusion no. Well not only at densities far beyond those in Jupiter or in test tubes on Earth.
b) It's not 100 times.
c) Tidal effects cause Io' volcanic activity.
e) Tidal effects cause Io' volcanic activity.

Redaction: Jeffery, 2001jan01

---

027 qmult 01100 1 4 1 easy deducto-memory: Galilean moons
14. The 4 Galilean moons of Jupiter are:

a) Callisto, Ganymede, Europa, and Io.
b) Callisto, Ares, Iolaus, and Pseudolus.
c) Callisto, Ganymede, Europa, and Phobos.
d) Callisto, Ganymede, Asia, and Io.
e) Callisto, Ganymede, Africa, and Io.

SUGGESTED ANSWER: (a)

Wrong answers:
b) Strictly for fans of *The Legendary Journeys of Hercules.*
c) Phobos is a Martian moon.
d) Asia should have a moon.
e) Africa should have a moon.

Redaction: Jeffery, 2001jan01

---

027 qmult 01200 1 4 4 easy deducto-memory: Galilean moons
15. How many moons does Jupiter have?

a) 4 known moons circa 2004. There may be other undiscovered, small moons. The 4 moons are, of course, the Galilean satellites discovered by **Rembrandt**.
b) 4 known moons circa 2004. There may be other undiscovered, small moons. The 4 moons are, of course, the Galilean satellites discovered by **Galileo.**
c) 1001.
d) 16 known moons circa 2004. There may be other undiscovered, small moons.
e) 6 known moons circa 2004. These moons include the 4 Galilean satellites and the two small moons, **Phobos and Deimos**. There may be other undiscovered, small moons.

SUGGESTED ANSWER: (d) See Cox-302.

Wrong answers:
a) Rembrandt in his telescopic phase.
b) There are lots of known small moons.
c) Not this many. Not one for each storied night of Scheherazade.
e) Phobos and Deimos are the two Martian moons.

Redaction: Jeffery, 2001jan01

---

027 qmult 01300 1 4 4 easy deducto-memory: Galilean moon orbital plane
16. The Galilean moons of Jupiter orbit more or less in a single plane probably because:

a) the early solar nebular magnetic field forced them to form in a plane.
b) of pure luck.
c) of pure bad luck.
d) they formed out the disk of material that formed about the proto-Jupiter.
e) a passing giant protoplanet pulled them into a plane long after their formation.

SUGGESTED ANSWER: (d) See Lissauer 1993, ARA&A, 31, 129, p. 161 for circumplanetary disks. But I also wonder if the equatorial bulge of Jupiter could have perturbed them into a single plane. Jupiter's equator is only 3.12° tilted to the the ecliptic plane. However, the Galilean moon orbits are more closely aligned to the ecliptic than to the equatorial plane. I think answer (d) is probably mostly right.

Wrong answers:
c) Why bad?

Redaction: Jeffery, 2001jan01

---

027 qmult 01400 2 4 3 deducto-moderate memory: Galilean moon surfaces
17. The surfaces of the Jupiter's Galilean satellites can be summarized as follows:

a) Callisto (old dark icy), Ganymede (old dark icy in parts; newer icy in parts), Europa (sulfurous and volcanic), Io (**methane ice**).

b) **Triton** (methane ice), Ganymede (sulfurous icy), Europa (sulfurous and volcanic), Io (**methane ice**).
c) Callisto (old dark icy), Ganymede (old dark icy in parts; newer icy in parts), Europa (newer brighter icy), Io (**sulfurous and volcanic**).
d) **Triton** (old dark icy), Ganymede (old dark icy in parts; newer icy in parts), Europa (newer brighter icy), Io (**sulfurous and volcanic**).
e) Callisto (old dark icy), Ganymede (old dark icy in parts; newer icy in parts), Europa (newer brighter icy), Io (**iron oxide**).

SUGGESTED ANSWER: (c)

Wrong answers:
b) Triton is a Neptune moon.
d) Triton is a Neptune moon.

Redaction: Jeffery, 2001jan01

---

027 qmult 01600 2 4 4 moderate deducto-memory: Io's colors
18. The striking (garish?) colors of Io are caused by:

a) rainbows. b) molecular oxygen gas. c) volatile gases such as molecular hydrogen, helium, and water vapor. d) sulfur and sulfur compounds. e) orange-colored water ice.

SUGGESTED ANSWER: (d) See Se-507 for sulfur. Sulfur is in the reading on Io and should probably be mentioned often in the Io connection.

Wrong answers:
a) There is no (or at least not much) liquid water on Io. But other clear fluid droplets could make rainbows? Well, I suppose, but it's not the right answer anyway. Who would describe rainbows as garish?
b) Molecular oxygen is a clear gas: look around you. I think this is always true.
c) Molecular hydrogen and helium are clear gases (FMW-217). So is water vapor in all conditions I think?
e) Io has no volatiles and isn't an ice-covered moon like the other 4 Galilean satellites. Galileo named them the Medicean moons for his patrons, the Medici.

Redaction: Jeffery, 2001jan01

---

027 qmult 01800 2 4 2 moderate deducto-memory: Io's ejected matter
19. The volcanoes on Io eject a lot of:

a) carbon in various forms. b) sulfur in various forms. c) helium gas. d) molecular oxygen. e) sulfur dioxide ice crystals.

SUGGESTED ANSWER: (b) Se-507–509 isn't explicit, but I assume SO_2 and sulfur compounds and ions of various kinds.

Wrong answers:
a) carbon compounds are usually volatiles and have been baked away long ago, but this is perhaps not an obvious conclusion.
c) helium gas is a volatile and has been baked away long ago, but this is perhaps not an obvious conclusion.
d) molecular oxygen is not a very common state for oxygen. On Earth photosynthesis is needed to get it.

e) sulfur dioxide ice crystals from a volcano?

Redaction: Jeffery, 2001jan01

---

028 qmult 04000 2 4 2 moderate deducto-memory: Saturn's ring material

20. The Saturnian rings (i.e., the bright rings of Saturn) consist mainly of:

a) carbon in various forms.
b) **WATER ICE** chunks in a range of sizes from billiard ball size to house size. Their icy content makes the rings highly **REFLECTIVE** and this is a main reason why the Saturnian rings are so much brighter than other gas giant rings.
c) **HELIUM ICE** chunks in a range of sizes from billiard ball size to house size. Their icy content makes the rings highly **REFLECTIVE** and this is a main reason why the Saturnian rings are so much brighter than other gas giant rings.
d) **WATER ICE** chunks in a range of sizes from billiard ball size to house size. Their icy content makes the rings highly **LIGHT-ABSORBING** and this is a main reason why the Saturnian rings are so much brighter than other gas giant rings.
e) **HELIUM ICE** chunks in a range of sizes from billiard ball size to house size. Their icy content makes the rings highly **LIGHT-ABSORBING** and this is a main reason why the Saturnian rings are so much brighter than other gas giant rings.

SUGGESTED ANSWER: (b) See FMW-242 and HI-209.

Wrong answers:

c) Helium becomes a liquid at about 4 K. I don't know if it ever becomes a solid under its own vapor pressure. Under high pressure supposedly it will become a solid. But in open space helium would be in a vacuum, and so shouldn't solidify. See CAC-54.

Redaction: Jeffery, 2001jan01

---

028 qmult 08000 1 4 4 easy deducto-memory: Cassini division

21. "Let's play *Jeopardy*! For $100, the answer is: It is an apparent gap in the rings of Saturn."

What is the _____, Alex?

a) Verdi vacancy b) Vivaldi separation c) Puccini gap d) Cassini division e) Salieri split

SUGGESTED ANSWER: (d) Everything I know about classical music, I learnt from listening to Gilmours Albums on the CBC radio station every Saturday morning before Clyde Gilmour passed on circa 1990 and left high culture bereft.

Wrong answers:

e) You remember *Amadeus* and that vile intriguer. Actually Antonio Salieri and Mozart got a long quite well; they had a jolly evening together shortly before Mozart passed on. It was his doctors—they killed Mozart with all there bleedings.

Redaction: Jeffery, 2001jan01