Astronomy 102A: Final Exam
2005 May 10 Tuesday

Instructions: There are 144 multiple-choice questions and the test is out of 144 marks. Choose the BEST answer, completion, etc., and darken fully the appropriate circle on the TABLES provided on pages 2 and 3. Read all responses carefully. NOTE that long, detailed responses won’t depend on hidden keywords: keywords in such responses are BOLD-FACED capitalized.

This is a CLOSED-BOOK exam. NO cheat sheets allowed. Calculators are permitted. This a 2 hour exam. Remember your name (and write it down on the exam too). DO NOT discuss the test with those in any section who have not taken it.

You must show a photo id when handing in the exam.
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001 qmult 01700 1 1 1 easy memory: planets move about the Sun

1. To very good approximation the planets move in:
   a) elliptical orbits with the Sun at one focus of the ellipse.
   b) circular orbits with the Sun at circle center.
   c) elliptical orbits with the Sun at the center of ellipse. (The center of the ellipse is
      where the major and minor axes cross.)
   d) planar orbits with the Sun at plane center.
   e) spherical orbits with the Sun at sphere center.

SUGGESTED ANSWER: (a)

Wrong answers:
   b) To fair approximation the planets do move in circular orbits with the Sun at
      circle center. Perhaps, one could even say to good approximation, not very
      good approximation I’d say. Anyway answer (a) is better.
   d) Planar orbits? Well I suppose in the sense that elliptical orbits are confined
      to a plane. But does a plane have a center?
   e) What are spherical orbits?

Redaction: Jeffery, 2001Jan01

002 qmult 00310 2 4 2 moderate deducto-memory: parallax of astro-bodies

2. “Let’s play Jeopardy! For $100, the answer is: This condition of astro-bodies means
   that they show no parallax to unaided-eye observations for any movements about the
   Earth’s surface.”

   What is their ____________, Alex?
   a) closeness relative to the size of the Earth   b) remoteness relative to the size
       of the Earth   c) spherical nature   d) reflectivity   e) sensitivity

SUGGESTED ANSWER: (b)

Wrong answers:
   a) Exactly wrong.

Redaction: Jeffery, 2001Jan01

002 qmult 00900 2 4 3 moderate deducto-memory: declination defined

3. What is declination?
   a) The point directly below.
   b) The point directly above.
   c) The angular position of an object measured north or south from the celestial
      equator.
   d) The angular position of an object measured east or west from the celestial equator.
   e) The azimuthal angular position of an object measured east from the vernal (or
      spring) equinox.

SUGGESTED ANSWER: (c)
Wrong answers:
   a) This is nadir.
   b) This is zenith.
   d) Not east, not west.
   e) This right ascension. See Skilling p. 55–57. Who is Skilling?

Redaction: Jeffery, 2001 jan01

002 qmult 02400 1 1 1 easy memory: Polaris on horizon
4. Polaris is on the horizon. You are:
   a) near the equator.       b) in New York City.       c) in Las Vegas.       d) near the north pole.       e) over the rainbow.

SUGGESTED ANSWER: (a)

Wrong answers:
   e) I wouldn’t deny it if I were you.

Redaction: Jeffery, 2001 jan01

002 qmult 03100 3 4 2 tough deducto-memory: gnomon shadow
5. Say you are in the northern hemisphere and have a gnomon (a stick set in the ground and set perpendicular to the ground). It is the winter solstice and noon. It is sunny and clear.

a) The shadow of the gnomon points due SOUTH.
   b) The gnomon has its shortest shadow for that day, but it has its LONGEST noon shadow of the year.
   c) The gnomon shadow points due EAST and it is the longest it can be for that day.
   d) The gnomon has no shadow.
   e) The gnomon has its shortest shadow for that day and it has its SHORTEST noon shadow of the year.

SUGGESTED ANSWER: (b) A lot of facts have to be put together.

Wrong answers:
   d) Now Gnomon may not see his shadow, but he does have one.

Redaction: Jeffery, 2001 jan01

000 qmult 00100 1 1 4 easy memory: scientific method
Extra keywords: physci KB-24-1 but much altered
6. The scientific method can be schematically described as:

   a) an inward spiral of theorizing and experiment/observation.   b) an integrative process.
   c) a reductive process.   d) a cycle of theorizing and experiment/observation.
   e) a pointless pursuit.

SUGGESTED ANSWER: (d)
Wrong answers:
b) Say what?
c) Say what?
e) As Lurch would say: “Aaaarh.”

Redaction: Jeffery, 2001

004 qmult 00020 1 1 5 easy deducto-memory: neolithic astronomy
7. Moon-shaped cut marks on bones in groupings of order 30 from neolithic times (as long ago as 36,000 BCE) suggest that people then were doing astronomy by:

   a) whiling away the time.  b) counting sheep.  c) wittling.  d) counting fingers and toes.  e) counting days of the lunar month.

SUGGESTED ANSWER: (e) See No-xxiv and Cox-16.

Wrong answers:
a) As Lurch would say: “Aaaarh.”

Redaction: Jeffery, 2001

004 qmult 03010 1 4 4 easy deducto-memory: Earth/heaven physics
8. “Let’s play Jeopardy! For $100, the answer is: This person’s work made astronomy in a sense and to a degree an experimental science in that he/she showed that the same physics applies on Earth and in the heavens.”

Who is __________, Alex?


SUGGESTED ANSWER: (d)

Wrong answers:
a) Old Ben was great scientist, but mathematical astronomy was not his forte.
e) He tried to go there, but didn’t really make it.

Redaction: Jeffery, 2001

001 qmult 00120 1 1 2 easy memory: megaparsec
9. A megaparsec (Mpc) is a unit typically used for:

   a) interstellar distances.  b) intergalactic distances.  c) terrestrial distances.  d) foot races.  e) horse races.

SUGGESTED ANSWER: (b)

Wrong answers:
a) Parsecs are used in this case.
e) Furlongs are used here: a furlong is an eighth of a mile or 220 yards.

Redaction: Jeffery, 2001
001 qmult 00220 1 3 3 easy math: length of year in seconds
10. The length of a Julian year of 365.25 days in seconds is:

   a) 60 s.        b) 86400 s.        c) about $\pi \times 10^7$ s.        d) about $10^5$ s.        e) about $2.2 \times 10^6$ s.

**SUGGESTED ANSWER:** (c) It is just a concidence, but the length of a year is $\pi \times 10^7$ s to within 0.5%.

Fortran Code

```
print *
xjyr=365.25
daysec=86400.
yearsec=xjyr*daysec
pi=acos(-1.)
print*, 'yearsec,yearsec*1.e-7/pi'
print*,yearsec,yearsec*1.e-7/pi
* 3.15576e+07   1.00451
```

Wrong answers:

b) This is the length of a day.
d) This is the rounded-off to 1 significant figure length of a day.

**Redaction:** Jeffery, 2001jan01

001 qmult 00600 1 3 2 easy math: Earth speed on equator
11. The Earth rotates once a day and has an equatorial radius of 6378 km. What is the speed of a point on the equator relative to a system orbiting with the Earth, but not rotating?

   a) 1 km/s.        b) 0.46 km/s.        c) $3 \times 10^5$ km/s.        d) 1 km.        e) 0.46 km.

**SUGGESTED ANSWER:** (b) In this question we can ignore the small difference between solar and sidereal day. It makes most sense to use the sidereal day, but that day is a bit less than the 24 hour standard solar day. In fact the standard solar day is actually a bit less than the true mean solar day. The solar day is slowly increasing in time and the standard solar day was chosen to agree with the true mean solar day of about 1900.

Fortran Code

```
print *
pi=acos(-1.)
raheartheq=6.378136e+6  ! Cox-340
daysec=86400.
daysid=.99726968
veq=2.*pi*raheartheq/daysec  ! This is, of course relative to Sun.
print*, 'The synodic equatorial speed is ' ,veq  ! 463.831
m/s
```
\[ \text{veq} = 2. \pi \times \text{radertheq} / (\text{daysec} \times \text{daysid}) \] ! This is relative to fixed stars

\text{print*,'The sidereal equatorial speed is ',veq} ! 465.101 m/s

\text{acf = veq**2 / radertheq}

\text{print*,'The equatorial centrifugal force per mass is ',acf} ! 3.39157E-02

Wrong answers:
c) This is the speed of light.
d) Wrong units.
e) Wrong units.

Redaction: Jeffery, 2001 jan01

001 qmult 01100 2 3 4 moderate math: light travel time to Pluto
12. Pluto is about 40 astronomical units from the Sun. One astronomical unit is about \(1.5 \times 10^{13}\) cm. The speed of light is \(3.00 \times 10^{10}\) cm/s. The light travel time from the Sun to Pluto is:

a) \(2 \times 10^3\) s or about half an hour.   b) \(2 \times 10^3\) s or about 5.5 hours.
c) \(3.6 \times 10^3\) s or one hour.   d) \(2 \times 10^4\) s or about 5.5 hours.   e) \(2 \times 10^4\) s or about 8 hours.

SUGGESTED ANSWER: (d) People have to recall that distance divided by speed is travel time. They have to get the distance in the right units.

Wrong answers:
b) This is inconsistent.
e) Likewise is inconsistent.

Redaction: Jeffery, 2001 jan01

001 qmult 01330 2 4 4 moderate deducto-memory: star angular separation
13. Two stars are a fist width’s apart on the sky. (The fist is at arm’s length.) What is the angular separation of the two stars? How far apart are they in space?

a) The angular separation is about \(100^\circ\) and the stars are separated by about 100 light-years.
b) The angular separation is about \(360^\circ\) and the stars are separated by about 360 light-years.
c) The angular separation is about \(10^\circ\) and the stars are separated by about 10 light-years.
d) The angular separation is about \(10^\circ\). The spatial separation \textbf{CANNOT} be determined from the given information.
e) The angular separation is about 1 arcsecond. The spatial separation \textbf{CANNOT} be determined from the given information.

SUGGESTED ANSWER: (d) See Se-18.

Wrong answers:
a) 100° is more than a quadrant separation. Nobody’s fist at arm’s length is that large. The spatial separation is indeterminate in this question.

b) Angular separation by 360° is 0° angular separation.

d) One arcsecond separation is really too small.

Redaction: Jeffery, 2001 Jan 01

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001 qmult 01400 1 4 1 easy deducto-memory: linear function

14. A straight line on a plot represents a/an _________ function.

   a) linear  b) inverse-square  c) quadratic  d) logarithmic

   e) perpendicular

SUGGESTED ANSWER: (a) Line, linear: it makes sense right.

Wrong answers:

   e) As Lurch would say: “Aaaarh.”

Redaction: Jeffery, 2001 Jan 01

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003 qmult 00300 1 4 2 easy deducto-memory: Moon phase sunset

15. At sunset you see the Moon in the western sky. It is

   a) a waning crescent.  b) a waxing crescent.  c) a full moon.  d) a gibbous moon.  e) partially eclipsed.

SUGGESTED ANSWER: (b)

Wrong answers:

   e) As Lurch would say: “Aaaaah.”

Redaction: Jeffery, 2001 Jan 01

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003 qmult 00600 1 4 2 easy deducto-memory: Moon phase horned

16. The Moon is a crescent—the horned Moon. Which way, in a rough sense, do the horns point relative to the Sun?

   a) Toward the Sun.  b) Away from the Sun.  c) They can have any orientation depending on the time of year.  d) They can have any orientation depending on the time of day.  e) Perpendicular to the line from the Moon to the Sun.

SUGGESTED ANSWER: (b) The illuminated face of the Moon always points toward the Sun. Therefore the bow of the crescent must be toward the Sun and the horns away.

Wrong answers:

   a) This would look really weird.

Redaction: Jeffery, 2001 Jan 01

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003 qmult 00710 2 5 3 moderate thinking: intercalary month
17. The mean lunar month is 29.53059 days. How many days are there in a year of 12 mean lunar months and approximately how many years on a luni-solar calendar before you need to insert a 13th lunar month in a year (an intercalary month) in order to keep the luni-solar calendar roughly consistent with the Sun and seasons?

   a) 29.53059 days and every twelfth of a year.
   b) 365.25 days and every 3 solar years.
   c) 354.367 days and every 3 SOLAR YEARS. Note you won't get perfect consistency with an every 3 solar year insertion since your luni-solar calendar will be short about 33 DAYS after 3 solar years and a mean lunar month is only 29.53059 days.
   d) 365.25 days and every 300 years.
   e) 354.367 days and every 4 SOLAR YEARS. Note you won't get perfect consistency with an every 4 solar year insertion since your luni-solar calendar will be short about 33 DAYS after 4 solar years and a mean lunar month is only 29.53059 days.

SUGGESTED ANSWER: (c) Note that the difference between 12 lunar months and a solar year is about 365.24 - 354.37 = 10.87, and so after 3 years the discrepancy is about 32.61 or 33 days.

Many societies tried to keep a 12 lunar month calendar and a solar calendar at the same time: i.e., a luni-solar calendar. Since 12 mean lunar months is 354.367 days and the solar (i.e., tropical) year is about 365.2421897 days (Cox-15), the 12-lunar-month year would run a head of solar time in year count by about 32.6254 days every 3 years. In order to keep the months from moving out of their seasons, a 13 month (an intercalary month) had to be inserted into the calendar a bit more frequently than every 3 years. In fact, if you have 12 12-lunar month years and 7 13-month years (i.e., 235 lunar months equal to 6939.69 days) in 19 tropical years (6939.60 days), then the lunar and solar time-keeping stay consistent for a very long time: a discrepancy of only about a tenth of day adds on every 19-year cycle. The 19-year cycle is called the Metonic cycle after the Athenian astronomer Meton (late 5th century BCE) who may have been the first to discover it (Ne-7).

Fortran Code

```fortran
print*
xlunar=29.53059 ! Cox-16
xsolar=365.2421897 ! Cox-15
xyear=12.*xlunar
dif=3.*(xsolar-xyear)
xlun=12.*12.*xlunar+7.*13.*xlunar
xsol=19.*xsolar
print*,xyear,dif,xlun,xsol'
print*,xyear,dif,xlun,xsol
* 354.367 32.6254 6939.69 6939.60
```

Wrong answers:

a) As Lurch would say: “Aaaarrh.”
Redaction: Jeffery, 2001 Jan 01

003 qmult 00900 1 3 2 easy math: lunar angular speed sidereal
18. The mean lunar sidereal period is 27.322 days. The angular velocity of
the Moon relative to the fixed stars is:

   a) 12.19° per day.   b) 13.18° per day.   c) 27.32° per day.   d) 360° per
day.   e) 13.18°.

SUGGESTED ANSWER: (b) This could be done by straight memory, but
it is intended to be a calculational problem. The student must realize that a
complete sidereal period takes the Moon through 360° relative to the fixed stars.
Then 360°/27.322 days = 13.18° per day.

Wrong answers:
   a) This is the angular velocity relative to the Sun.
   c) This number looks suspiciously over-familiar.
   d) This number looks suspiciously fast.
   e) This has wrong units.

Redaction: Jeffery, 2001 Jan 01

003 qmult 01200 1 4 5 easy deducto-memory: Earth focus of ellipse
19. The Earth is at:

   a) the geometrical center of the Moon’s elliptical orbit.
   b) the geometrical center of the Moon’s ecliptical orbit.
   c) both foci (i.e., focuses) of the Moon’s elliptical orbit.
   d) the perigee of the Moon’s orbit.
   e) one of the foci (i.e., focuses) of the Moon’s elliptical orbit.

SUGGESTED ANSWER: (e) Two isolated gravitationally bound bodies orbit
in ellipses with their mutual center of mass at one of the foci of the ellipses. If
one body is much more massive than the other, it is effectively at the center of
mass. In the Earth-Moon system, the Earth is very much the dominant mass,
and the Earth’s center is nearly at the center of mass relatively speaking. So it
makes sense in many cases to say the Moon orbits the Earth with the Earth at
one focus of the elliptical orbit. But if one is dealing with the Earth’s tides, one
does have take into consideration the Earth’s orbiting the center of mass.

Wrong answers:
   a) A geometrical center is not a focus.
   b) Elliptical, not ecliptical. The similarity of these two words is sometimes
      confusing, but their meanings are distinct.
   c) The Earth is not in two places at once.
   d) The Earth is never at the perigee of the Moon’s orbit; the Moon, however,
      is there once per orbit.

Redaction: Jeffery, 2001 Jan 01
20. A lunar eclipse can occur only when the Moon is:

a) a crescent.  b) half full.  c) gibbous.  d) full.  e) waning gibbous.

SUGGESTED ANSWER:  (d) The Moon can't be in the Earth's shadow unless it's opposite the Sun: i.e., it's full.

Wrong answers:
b) When half full the Moon is at a right angle to the Sun as seen from Earth.

Redaction: Jeffery, 2001jan01

21. From the penumbra of the Earth, the:

a) Sun cannot be seen at all.  b) Moon cannot be seen at all.  c) stars cannot be seen.  d) planets cannot be seen.  e) Sun is partially visible.

SUGGESTED ANSWER:  (e)

Wrong answers:
d) As Lurch would say: "Aaaarh."

Redaction: Jeffery, 2001jan01

22. “Let’s play Jeopardy! For $100, the answer is: In this kind of solar eclipse a ring of photosphere of the Sun is seen around the dark moon.”

What is a/an ____________, Alex?

a) total solar eclipse  b) partial solar eclipse  c) annular solar eclipse  d) ring eclipse  e) diamond ring eclipse

SUGGESTED ANSWER:  (c)

Wrong answers:
a) A total eclipse is when the Moon is close enough to the Earth to cover the whole photosphere.  
d) A sensible name since “annular” means ring-like, but these eclipses aren’t called annular.  
e) There is a diamond ring effect when the photosphere of the Sun just peeps through a valley or the like of the Moon just before/after totality.

Redaction: Jeffery, 2001jan01

23. Drop a feather and hammer at the same time on the Earth and then on the Moon.

a) They both hit the ground at the same time on both worlds.  
b) The hammer lands first by a large margin on both worlds.  
c) The feather lands first on both worlds.
d) The **feather** lands second on Earth and at about the same time as the **hammer** on the Moon.
e) The **feather** lands second on Earth and first by a large margin on the Moon.

**SUGGESTED ANSWER: (d)**

**Wrong answers:**
- a) The air resistance on Earth slows down the feather.
- b) On the Moon, the air resistance is negligible.

**Redaction:** Jeffery, 2001 jan01

005 qmult 00500 1 1 5 easy memory: Newton’s 3rd law
24. Newton’s 3rd law states:

- a) for every force, there is an **EQUAL** and **PERPENDICULAR** force.
- b) for every force, there is an **SMALLER** and **PERPENDICULAR** force.
- c) for every force, there is an **EQUAL** and **OPPOSITE** force. The two forces act on the same body always, and so their are no accelerations at all.
- d) for every force, there is a **LARGER** and **OPPOSITE** force.
- e) for every force, there is an **EQUAL** and **OPPOSITE** force.

**SUGGESTED ANSWER: (e)**

**Wrong answers:**
- c) Accelerations do happen.

**Redaction:** Jeffery, 2001 jan01

005 qmult 00580 2 5 3 moderate thinking: Newton’s laws not obvious
25. Newton’s laws of motion are:

- a) obvious. This is why Aristotle knew them more than 23 centuries ago. He just rejected them for moral reasons.
- b) not obvious. Nevertheless, Aristotle knew of the them more than 23 centuries ago. He just rejected them for hygienic reasons.
- c) not obvious. To get to them, one probably first has to imagine what happens in the absence of all resistive media.
- d) 6 in number.
- e) not obvious. To get to them, one probably first has to imagine what happens in the center of the Earth.

**SUGGESTED ANSWER: (c) This is really a thinking question, if the Professor has not spoken ex cathedra.**

**Wrong answers:**
- a) If Newton’s laws were obvious, why did they take so long to be discovered and why don’t students just know them.
- b) Aristotle: not likely.
- d) There are only 3.
- e) The center of the Earth is a red herring.
Redaction: Jeffery, 2001 jan 01

005 qmult 01010 1 5 4 easy thinking: inverse-square law of gravity 2
26. The force of gravity between two bodies is proportional to the inverse square of the distance between the centers of the two bodies either exactly or approximately depending on nature of the bodies. At 100 Earth radii, the Earth’s gravity force is _______ times its gravity force on its surface.

   a) 1/100      b) 1/200      c) 200      d) 1/10000      e) zero

SUGGESTED ANSWER: (d) People do have to understand what an inverse square law means.

Wrong answers:
   a) This would be the result of just an inverse law.

Redaction: Jeffery, 2001 jan 01

005 qmult 01270 1 4 4 easy deducto-memory: orbital free fall
27. Astronauts in orbit about the Earth are weightless because:
   a) gravity vanishes in space.
   b) gravity becomes repellent in space.
   c) they are in free fall. They are perpetually falling away from the Earth.
   d) they are in free fall. They are perpetually falling toward the Earth, but keep missing it.
   e) they are in free fall. But they reach terminal speed due to air resistance and this hides any effects of acceleration.

SUGGESTED ANSWER: (d)

Wrong answers:
   a) Gravity doesn’t vanish in space. Why do the planets keep orbiting the Sun.
   b) Gravity is always attractive.
   c) But they are always falling towards the Earth.
   e) The answer is plausible nonsense. There is, of course, some air resistance in low orbit, but that doesn’t account for free fall.

Redaction: Jeffery, 2001 jan 01

005 qmult 01402 1 3 2 easy math: kinetic energy and velocity
28. The formula for kinetic energy is

\[ KE = \frac{1}{2}mv^2, \]

where \( m \) is mass and \( v \) is velocity. If velocity is doubled, kinetic energy changes by a multiplicative factor of:

   a) 2.      b) 4.      c) 1/2.      d) 1/4.      e) 1 (i.e., it is unchanged).

SUGGESTED ANSWER: (b)
**Wrong answers:**
e) As Lurch would say: “Aaarh.”

**Redaction:** Jeffery, 2001 Jan 01

005 qmult 01500 1 4 3 easy deducto-memory: Fundy Tides

29. The world’s largest tidal range is:

   a) of order 0.5 m in the deep oceans.   b) 1 m in the Bay of Fundy.   c) 12 m or more in the Bay of Fundy.   d) 0.1 m or less in the Bay of Fundy.   e) 12 m or more in Lake Erie.

**Suggested answer:** (c) Wells, p. 247, says 14 meters; Defant, p. 14, says almost 70 feet or 20 odd meters: there may be no inconsistency; Defant may be just pointing to an extreme case even for Fundy. But I don’t recall who Wells or Defant are. But Seeds (Se-37) says 12 meters or more, and I’ll rely on that.

**Wrong answers:**
a) This is about the size of deep ocean tides, but they aren’t the world’s largest.

   No one I can find gives a consistent answer on the real range of deep ocean tides.

   b) Right place, wrong range.

   d) Right place, wrong range.

   e) Lake Erie. Come on. Port Colborne would be washed away.

**Redaction:** Jeffery, 2001 Jan 01

006 qmult 00052 1 4 2 easy deducto-memory: fireworks sound and flash

30. At fireworks displays, the explosions produce a light flash and sounds.

   a) The sound is heard before the flash is seen.

   b) The flash is seen before the sound is heard.

   c) Sound and flash come simultaneously.

   d) The sound is seen before the flash is heard.

   e) Neither effect is noticed by the spectators.

**Suggested answer:** (b)

**Wrong answers:**

   b) No.

   d) Sound seen? Flash heard?

   e) The old pointless firework display.

**Redaction:** Jeffery, 2001 Jan 01

006 qmult 00200 2 4 3 moderate deducto-memory: waves and photons

31. Electromagnetic radiation (EMR) is:

   a) a wave phenomenon. The propagation speed is that of sound.

   b) a wave phenomenon. However, EMR also acts as if it came in packets called protons.
c) a wave phenomenon. However, EMR also acts as if it came in packets called **photons**.

d) a wave phenomenon. However, EMR also acts as if it came in packets called **electrons**.

e) a particle phenomenon.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**
a) Sound?

**Redaction:** Jeffery, 2001 jan 01

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006 qmult 00530 2 1 3 moderate memory: visible light range

**Extra keywords:** CK-91-key-3

32. The wavelength range of visible light is about:

a) 1–20 cm.   b) 0.1–10 nm.   c) 400–700 nm.   d) 700–1000 nm.   e) 0.700–1000 microns.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**
e) This is, more or less, the infrared band.

**Redaction:** Jeffery, 2001 jan 01

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007 qmult 00010 1 1 3 easy memory: ion defined

**Extra keywords:** CK-110-ion

33. An ion is a:

a) synonym for an atom.   b) neutral atom.   c) charged atom.   d) molecule.   e) proton.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**
e) Well a bare proton is the hydrogen ion, but an ion is not a proton.

**Redaction:** Jeffery, 2001 jan 01

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007 qmult 00600 2 1 5 moderate memory: blackbody spectrum and temperature

34. A solid, liquid, or dense gas at a uniform temperature (in addition to any reflected light) will:

a) radiate a line spectrum.

b) radiate a greybody spectrum.

c) radiate nothing.

d) radiate a blackbody spectrum which is a universal spectrum that depends on **NO PROPERTIES** of the radiating body.

e) radiate a blackbody spectrum which is a universal spectrum that depends **ONLY** on the absolute (i.e., Kelvin scale) temperature of the radiating body.
SUGGESTED ANSWER: (e)

Wrong answers:
  d) It depends on temperature.

Redaction: Jeffery, 2001 jan 01

007 qmult 00660 1 3 3 easy math: using Wien’s law for a human
35. Wien’s law for blackbody spectra is

\[ \lambda_{\text{micron}}^{\text{max}} \approx \frac{2898 \text{ micron-K}}{T}. \]

The average, healthy, resting human has a body temperature of about 310 K. Assuming the human radiates like a black body, what is the approximate wavelength of the peak of the black-body emission? About _______ microns which is _______ light.

  a) 0.1; red    b) 0.1; ultraviolet  c) 10; infrared  d) 10; red    e) 3; red

SUGGESTED ANSWER: (c)

Wrong answers:
  d) We don’t look all red do we?

Redaction: Jeffery, 2001 jan 01

007 qmult 00802 1 4 2 easy deducto-memory: photosphere defined II

Extra keywords: Sun-question
36. “Let’s play Jeopardy! For $100, the answer is: The layer of a star (e.g., the Sun) from which most of the escaping electromagnetic radiation comes.”

What is the ________, Alex?

  a) nuclear-burning core    b) photosphere    c) chromosphere    d) corona    e) stellar wind

SUGGESTED ANSWER: (b)

Wrong answers:
  c) Probably lots of stars have chromospheres, but we can only observe the Sun’s in detail anyway.
  d) Probably lots of stars have coronas, but we can only observe the Sun’s in detail anyway.
  e) We know many stars have stellar winds. Some much stronger than the Sun’s.

Redaction: Jeffery, 2001 jan 01

008 qmult 00230 1 1 5 easy memory: Sun photosphere temperature
37. The temperature of the solar photosphere is about:

  a) 300 K.    b) 600 K.    c) 273 K.    d) 40000 K.    e) 6000 K.

SUGGESTED ANSWER: (e)
**Wrong answers:**

c) This is the freezing temperature of water.

**Redaction:** Jeffery, 2001 jan01

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38. The solar constant (i.e., the electromagnetic radiation energy per unit time per unit area from the Sun at the top of the Earth’s atmosphere) is

a) 1367 W/m$^2$.  
b) 1000.00 W/m$^2$.  
c) 0.  
d) $-1367$ W/m$^2$.  
e) infinite.

**SUGGESTED ANSWER:** (a)

**Wrong answers:**

b) Doesn’t this seem suspiciously round and precise for a physical variable that has not be defined to be round and precise.

e) As Lurch would say: “Aaaarh.”

**Redaction:** Jeffery, 2001 jan01

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39. “Let’s play *Jeopardy!* For $100$, the answer is: This astrophysical body has three main interior layers: 1) a core (in which thermonuclear reactions occur) that extents out to about 25% of the body’s radius; 2) a radiative transfer zone which extends out to about 71% of the body’s radius; 3) a convective zone that extends from about 71% of the body’s radius to the body’s surface.”

What is ____________, Alex.

a) the Moon  b) Venus  c) the Milky Way  d) the Earth  e) the Sun

**SUGGESTED ANSWER:** (e) See Cox-342.

**Wrong answers:**

a) No. It’s not the Moon.

**Redaction:** Jeffery, 2001 jan01

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40. A granule is:

a) a kind of cereal.

b) a grain of dust.

c) the top of a rising current of **HOT** gas in the Sun. Granules are seen in the solar photosphere. They last about 10 minutes and then lose their identity with their surroundings. The risen gas **COOLS** and then sinks.

d) the top of a rising current of **COLD** gas in the Sun. Granules are seen in the solar photosphere. They last about 10 minutes and then lose their identity with their surroundings. The risen gas **HEATS** up and then sinks.
e) a solar flare by another name.

**SUGGESTED ANSWER:** (c) If one remembers that granules are in the Sun then two answers are ruled out.

Cox-364 confirms that the mean lifetime of granules is 10 minutes.

**Wrong answers:**

- d) Rising matter in convection is hot.
- e) A rather stupid synonym if it were true.

**Redaction: Jeffery, 2001 jan01**

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008 qmult 00510 1 4 3 easy deducto-memory: five Sun outer layers I

41. The five outermost layers of the Sun (defining layers of the Sun generously) can be labeled:

- a) convection zone, photon, chromosome, coronation street, and solar sail.
- b) convection zone, photosphere, chromosphere, corona, and solar sail.
- c) convection zone, photosphere, chromosphere, corona, and solar wind.
- d) convection zone, photon, chromosome, corona, and glabron.
- e) construction zone, photosphere, chromosphere, corona, and glabron.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**

- a) You’ve got to be kidding.
- b) Not solar sail.
- d) A glabron is a nonce word meaning hairless particle. Just in case you needed to know.
- e) Construction zones are on Earth, cowboy.

**Redaction: Jeffery, 2001 jan01**

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008 qmult 00830 2 3 3 moderate math: solar wind mass loss II, Sun gone

42. The Sun loses mass by the solar wind at a rate of \( \sim 2 \times 10^9 \text{ kg s}^{-1} \sim 3 \times 10^{-14} \, M_{\odot}/\text{yr} \).

(\text{Note that } M_{\odot} \text{ is the standard symbol for a solar mass: i.e., the mass of the Sun.}) If this rate remained constant (which is highly unlikely), how long until the Sun is all gone? (Note a gigayear (Gyr) is a billion years.)

- a) \( \sim 10^{10} \text{ yr} = 10 \text{ Gyr} \).
- b) \( \sim 10^9 \text{ s} \).
- c) \( \sim 3 \times 10^{13} \text{ yr} = 3 \times 10^4 \text{ Gyr} \).
- d) \( \sim 5 \times 10^9 \text{ yr} = 5 \text{ Gyr} \).
- e) \( \sim 3 \times 10^{13} \text{ s} \).

**SUGGESTED ANSWER:** (c) Foukal, P. 1990. *Solar Physics*, (New York: John Wiley & Sons, Inc.), p. 436 coughs up this much hidden number \( 2 \times 10^{12} \text{ g/s} \) or \( 3 \times 10^{-14} \, M_{\odot}/\text{yr} \). Se-152 is wrong; FMW-293 is wrong too.

**Wrong answers:**

- e) Wrong units.

**Redaction: Jeffery, 2001 jan01**
008 qmult 01100 111 easy memory: sunspots defined
43. Sunspots are:
   a) dark spots on the Sun's surface.  b) bright spots on the Sun's surface.
   c) never observable.  d) larger than the Sun.  e) only a theory.

**SUGGESTED ANSWER:** (a)

**Wrong answers:**
b) Exactly wrong.

**Redaction:** Jeffery, 2001 jan01

038 qmult 00602 113 easy memory: luminosity defined II

**Extra keywords:** CK-276,277, Sun-question
44. A star's luminosity is its:
   a) apparent magnitude.  b) spectrum.  c) total power (energy per unit
time) in electromagnetic radiation.  d) total power (energy per unit time) in
neutrinos.  e) incandescence.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**
d) A star does have a neutrino power or luminosity, but that is not usually
considered part of its luminosity.
e) This usually the state of being white hot.

**Redaction:** Jeffery, 2001 jan01

041 qmult 00240 112 easy memory: strong nuclear force binds nuclei

**Extra keywords:** Sun-question
45. Nuclei are bound together by:
   a) gravity.  b) the strong nuclear force.  c) the electromagnetic force.
   d) the centrifugal force.  e) the weak nuclear force.

**SUGGESTED ANSWER:** (b)

**Wrong answers:**
d) As Lurch would say: "Aaaarh." This not a real force, but rather the tendency
of objects in a rotating frame to try to go in a straight line.

**Redaction:** Jeffery, 2001 jan01

041 qmult 00260 213 moderate memory: 4 hydrogen nuclei to 1 helium

**Extra keywords:** CK-262,267 Sun-question
46. In hydrogen burning how many hydrogen nuclei are **CONSUMED** in producing one
helium-4 nucleus (i.e., one $^4$He nucleus)?
   a) 1.  b) 2.  c) 4.  d) 10.  e) 6.5.
SUGGESTED ANSWER: (c)

Wrong answers:
e) Half a proton?

Redaction: Jeffery, 2001 Jan 01

47. 1 kg of matter is equivalent to about how much energy? Recall that the speed of light is $3.00 \times 10^8$ m/s.

a) $8 \times 10^{16}$ J. b) $9 \times 10^{16}$ J. c) $9 \times 10^8$ J. d) $3 \times 10^8$ J. e) $2 \times 10^8$ J.

SUGGESTED ANSWER: (b) Everyone must remember $E = mc^2$. We note that 1 megaton TNT yields $4.16 \times 10^{15}$ J explosion energy (WP-A-20) which I suppose counts both heat and macroscopic kinetic energy. Thus, if one could transform 1 kg of matter into explosive energy one would have a 20 megaton bomb. Fortunately, this reaction though energetically allowed is forbidden by other rules. We would, of course, like to change rest mass energy into useful energy in a controlled manner: i.e., controlled fusion.

Wrong answers: 
d) You forgot to square the c.

Redaction: Jeffery, 2001 Jan 01

48. Main sequence stars burn (in the nuclear sense):

a) helium to carbon in their cores. b) helium to carbon on their surfaces. c) helium to hydrogen on their surfaces. d) helium to hydrogen in their cores. e) hydrogen to helium in their cores.

SUGGESTED ANSWER: (e)

Wrong answers: 
b) As Lurch would say: “Aaahh.”

Redaction: Jeffery, 2001 Jan 01

49. “Let’s play Jeopardy! For $100$, the answer is: This is a set of calculated distributions of temperature, density, luminosity, and other physical quantities for a star.”

What is __________. Alex?

a) the star mass b) the star itself c) a model of the star d) the star luminosity e) the astronomical unit
SUGGESTED ANSWER: (c)

Wrong answers:
e) C’mon.

Redaction: Jeffery, 2001jan01

041 qmult 00500 1 4 3 easy deducto-memory: hydrostatic equilibrium
Extra keywords: Sun-question
50. Hydrostatic equilibrium means that:

a) pressure and other forces in a fluid are UNBALANCED, but the fluid is exhibiting a SMOOTH FLOW (at least in the reference frame of the fluid center of mass).
b) pressure and other forces in a fluid are UNBALANCED and the fluid is exhibiting a TURBULENT FLOW (at least in the reference frame of the fluid center of mass).
c) pressure and other forces in a fluid are BALANCED and there is NO FLUID MOTION (at least in the reference frame of the fluid center of mass).
d) the temperature is a constant throughout a fluid.
e) the temperature is not a constant throughout a fluid.

SUGGESTED ANSWER: (c) The answer should be determinable from the expression itself.

Wrong answers:
a) “Unbalanced” is not right for an expression containing the word “equilibrium.”

Redaction: Jeffery, 2001jan01

041 qmult 00520 1 1 2 easy memory: star pressure support
Extra keywords: CK-261, Sun-question
51. Main sequence stars of low mass are mainly supported against collapse ($\geq 90\%$ for $M \lesssim 8M_\odot$) by:

a) the pressure of liquid water. b) the ideal gas pressure of ions and electrons.
c) the gravitational force. d) angular momentum. e) the solar wind.

SUGGESTED ANSWER: (b) I vaguely thought that radiation pressure was important in the Sun. But no, Cl-163–165 shows that radiation pressure is close to negligible in low-mass main sequence stars.

Wrong answers:
c) Gravity is the force trying to cause collapse.
d) angular momentum gives a bit of support and helps to make the Sun bulge at the equator a bit, I suppose.

Redaction: Jeffery, 2001jan01

040 qmult 00200 1 1 5 easy memory: interstellar medium (ISM) defined 1
Extra keywords: CK-299,321, Sunlife
52. The interstellar medium (ISM) consists of:

   a) planets.   b) molecular clouds only.   c) stars.   d) dust only.   e) gas
   and dust.

SUGGESTED ANSWER: (e)

Wrong answers:
   a) As Lurch would say: “Aaaarh.”

Redaction: Jeffery, 2001 jan01

040 qmult 00330 2 1 5 moderate memory: molecular cloud composition
Extra keywords: CK-300, Sunlife
53. The composition of molecular clouds in the interstellar medium is dominated by:

   a) carbon dioxide.   b) molecular oxygen only.   c) helium gas only.
   d) amino acids.   e) molecular hydrogen gas and helium gas.

SUGGESTED ANSWER: (e) Hydrogen and helium dominate the composition of the universe and a molecular cloud should have molecules. Zeilik p. 332 confirms that the hydrogen in molecular clouds is molecular hydrogen.

Wrong answers:
   a) Carbon dioxide is an important tracer of molecular clouds, but it is a minority species.

Redaction: Jeffery, 2001 jan01

040 qmult 01510 2 4 2 moderate deducto-memory: disk formation frequency
Extra keywords: CK-304, Sunlife
54. Disk formation is:

   a) a unique event that happened only in the case of the formation of the Sun.
   b) a common event in star formation as far as astronomers can tell.
   c) a process in nuclear burning.
   d) never observed in star formation.
   e) responsible for the heating up of the protostar.

SUGGESTED ANSWER: (b)

Wrong answers:
   d) It has been observed.

Redaction: Jeffery, 2001 jan01

041 qmult 01020 2 4 2 moderate deducto-memory: main sequence brightening
Extra keywords: Sun-question, Sunlife
55. As a MAIN SEQUENCE STAR ages, its luminosity (i.e., total energy output):
a) decreases.  b) increases.  c) oscillates wildly.  d) becomes tangential.  e) incinerates.

**SUGGESTED ANSWER:** (b) See Se-246.

**Wrong answers:**

a) As the fuel is being exhausted this seems reasonable. But in fact the fuel burns more rapidly as it is expended.

d) A nonsense answer.

e) Luminosity is a characteristic of a substance, not a substance itself: the verb incinerate cannot apply to luminosity.

**Redaction:** Jeffery, 2001

042 qmult 00110 2 4 4 moderate deducto-memory: post-main sequence of Sun  
**Extra keywords:** Sunlife

56. After the end of its main sequence lifetime, the Sun will probably go through the following phases in order:

a) red giant, helium flash (a very short stage), horizontal branch star, green giant, cometary nebula/pre-white dwarf, white dwarf, black dwarf (very far in the future).

b) red giant, helium flash (a very short stage), horizontal branch star, jolly green giant, planetary nebula/pre-white dwarf, white dwarf, black dwarf (very far in the future).

c) red giant, helium flash (a very short stage), vertical branch star, second red giant (i.e., asymptotic [red] giant branch star or ABG star), cometary nebula/pre-white dwarf, white dwarf, black dwarf (very far in the future).

d) red giant, helium flash (a very short stage), horizontal branch star, second red giant (i.e., asymptotic [red] giant branch star or ABG star), planetary nebula/pre-white dwarf, white dwarf, black dwarf (very far in the future).

e) red giant, Larry, Curly, Moe, black dwarf (very far in the future).

**SUGGESTED ANSWER:** (d) See Se-250–252 and Sh-152. Note only stars in the 0.4–3 $M_\odot$ range have a helium flash.

**Wrong answers:**

e) Larry, Curly, Moe—you get it—Larry, Curly, ...

**Redaction:** Jeffery, 2001

042 qmult 00410 1 4 3 easy deducto-memory: AGB Sun vaporizes Earth  
**Extra keywords:** Sunlife

57. If in its AGB (asymptotic red giant) phase (or 2nd red giant phase), the Sun has expanded and enveloped the Earth, the Earth will:

a) very quickly collapse to a black hole.

b) become a red giant star.

c) spiral into the deeper layers of the Sun because of the drag forces of the Sun's outer layers. There the Earth will be totally vaporized. "So the glory of this
world passes away”: *Sic transit gloria mundi.*

d) gain escape velocity and be ejected from the solar system because of the drag forces of the Sun’s outer layers.

e) implode to form a protostar.

**SUGGESTED ANSWER:** (c) Zeilik p. 359 gives the Earth only about 200 years of survival after envelopment.


**Wrong answers:**

a) We haven’t discussed black holes, but I don’t think this answer would seem plausible compared to the others.

b) This is what the Sun is doing, not the Earth.

d) Drag forces slow down, they don’t accelerate. They always oppose motion.

e) The Earth is much too small to become a protostar and why would it do this.

**Redaction:** Jeffery, 2001 jan01

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042 qmult 00600 1 4 4 easy deducto-memory: planetary nebula defined

**Extra keywords:** CK-329,346 FK-493, Sunlife

58. A planetary nebula is:

a) a cloudy **planet**.

b) a cloud that will coalesce into a **planet**.

c) a shell of gas thrown off by a dying star before it becomes a **protostar**.

d) a shell of gas thrown off by a dying star before it becomes a **white dwarf**.

e) a shell of gas thrown off by a dying star before it becomes a **galaxy**.

**SUGGESTED ANSWER:** (d)

**Wrong answers:**

a) This answer should be really out of it.

**Redaction:** Jeffery, 2001 jan01

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020 qmult 00090 1 4 3 easy memory: evidence of solar system formation

59. We will probably never be able to understand how our solar system formed in exact detail, but can understand in more general terms how it formed by relying on various kinds of evidence: e.g.,

a) star formation regions that we observe, extrasolar planets (of which **111** are known as of 2004mar04), relics of the formation process (e.g., leftover planetesimals or fragments thereof including primitive meteorites), and **DINOSAUR FOSSILS**.

b) star formation regions that we observe, extrasolar planets (of which **1111** are known as of 2004mar04), relics of the formation process (e.g., leftover planetesimals or fragments thereof including primitive meteorites), and **BIOLOGY**.
c) star formation regions that we observe, extrasolar planets (of which 111 are known as of 200mar04), relics of the formation process (e.g., leftover planetesimals or fragments thereof including primitive meteorites), and MODELING.

d) star formation regions that we observe, extrasolar planets (of which 2 are known as of 2004mar04), relics of the formation process (e.g., leftover planetesimals or fragments thereof including primitive meteorites), and MODELING.

e) star formation regions that we observe, extrasolar planets (of which 111 are known as of 2004mar04), relics of the formation process (e.g., leftover planetesimals or fragments thereof including primitive meteorites), and WISHFUL THINKING.

SUGGESTED ANSWER: (c)

Wrong answers:
  e) If only wishful thinking actually worked.

Redaction: Jeffery, 2001jan01

020 qmult 00097 2 4 5 moderate deducto-memory: Kant’s nebular hypothesis

60. “Let’s play Jeopardy! For $100, the answer is: He/She was the first proposer of the nebular hypothesis for the origin of the solar system in the context of Newtonian physics.”

Who was ____________, Alex?

  a) composer Johann Sebastian Bach (1685–1750)  b) adventurer and writer
    Giovanni Jacopo Casanova (1725–1798)  c) astronomer Caroline Herschel
    (1750–1848)  d) English general and statesman John Churchill, Duke of
    Marlborough (1650–1722)  e) philosopher Immanuel Kant (1724–1804)

SUGGESTED ANSWER: (e)

Wrong answers:
  a) Da, da, da, da. No that was Beethoven.
  b) I don’t think Casanova had any mathematical interests, but he did obtain a
    doctorate of laws from the University of Padua: unfortunately, no record of
    this degree has been found.
  c) She was a comet hunter and a helpmeet (eek!!) to her brother William
    Herschel the leading observational astronomer of the 18th century.
  d) An ancestor of Winston Churchill: “He never walked off a battle field save
    as a victor; he never besieged a place he did not take.”

Redaction: Jeffery, 2001jan01

020 qmult 00400 1 3 1 easy math: radioactive dating, half-life U-238

61. A sample is initially pure radioactive $^{238}_{92}$U (an isotope of uranium). After four half-lives how much $^{238}_{92}$U is left?

  a) 1/16.  b) 1/2.  c) 1/4.  d) 1/10.  e) None.
SUGGESTED ANSWER: (a) People do need to remember what half-life means. For the half-life of $^{238}\text{U}$ see Enge-225.

Wrong answers:
e) Formally this only happens at infinite time for the ideal case of an infinite sample. But in fact for a finite sample many half-lives along you will reach a point where the formula predicts a fraction of an undecayed nucleus remaining. At that point the last nucleus is gone or will be in a finite (though perhaps) very long time.

Redaction: Jeffery, 2001jan01

020 qmult 01200 2 1 4 moderate memory: planetary formation sequence
62. The planetary formation sequence as currently understood is:

a) collective-self-gravitation/sticky accretion of gas to grains, condensation of grains to planetesimals, gravitational accretion of planetesimals to protoplanets.
b) collective-self-gravitation/sticky accretion of gas to grains, condensation of grains to planetesimals, second round of sticky accretion of planetesimals to protoplanets.
c) condensation of gas to grains, collective-self-gravitation/sticky accretion of grains to planetesimals, further sticky accretion of planetesimals to protoplanets.
d) condensation of gas to grains, collective-self-gravitation/sticky accretion of grains to planetesimals, gravitational accretion of planetesimals to protoplanets.
e) gravitational coalescence of gas to grains, collective-self-gravitation/sticky accretion of grains to planetesimals, gravitational accretion of planetesimals to protoplanets.

SUGGESTED ANSWER: (d) This can be just a straight moderate memory question, but some thought can narrow the answers down. Gravity only plays a role in larger body structure. Gases condense.

Wrong answers:
e) Not condensation of grains to planetesimals.

Redaction: Jeffery, 2001jan01

020 qmult 01650 1 4 1 easy deducto-memory: gas giant formation
63. “Let’s play Jeopardy! For $100$, the answer is: These solar system bodies are thought to form according to one of two possible theories. Theory 1: they start as rocky/icy protoplanets that are massive enough to gravitationally attract and hold abundant hydrogen and helium gas. Theory 2: they start as gravitationally collapsed dense cores of hydrogen and helium just as stars do and grow by further gravitational accretion of abundant hydrogen and helium.”

What are __________, Alex?

a) gas giant or Jovian planets     b) rocky or terrestrial planets     c) minor planets or an asteroids     d) Kuiper Belt objects or a trans-Neptunian objects     e) mirror matter planets
SUGGESTED ANSWER: (a)

Wrong answers:
  a) Rocky planets do not have abundant hydrogen and helium and no thinks
     they start forming just like stars.
  c) There is a theory—for which there is a shred of evidence even—that there is
     a mirror universe which interacts with our universe only be gravitation and
     few minor, obscure processes. In the mirror universe there are mirror planets
     that our just like ours one supposes.

Redaction: Jeffery, 2001 jan 01

020 qmult 02000 1 1 3 easy memory: chemical differentiation
64. In planet formation, the chemical differentiation stage is the stage:
   a) of heavy cratering.
   b) of heavy cratering and lava flows.
   c) where the molten materials of the early planets separated under the action of
      GRAVITY. The DENSER materials sank to the deeper regions; the LESS
      DENSE materials rose to the upper regions.
   d) where the molten materials of the early planets separated under the action of
      MAGNETIC FIELDS. The DENSER material sank to the deeper regions;
      the LESS DENSE materials rose to the upper regions.
   e) where the molten materials of the early planets separated under the action of the
      SOLAR WIND. The LESS DENSE material sank to the deeper regions; the
      DENSER materials rose to the upper regions.

SUGGESTED ANSWER: (c) Is the process chemical differentiation. Well
the process is physical, not chemical, but on the other hand it is the elements
(to which chemicals is often a synonym) that differentiate. Maybe elemental
differentiation is good.

Wrong answers:
  e) Not the solar wind.

Redaction: Jeffery, 2001 jan 01

021 qmult 00300 1 1 1 easy memory: internal structure of Earth
65. Three main ingredients in understanding the internal structure of the Earth are
   a) seismology, the primordial solar nebula composition, and modeling.
   b) seismology, the primordial solar nebula composition, and biology.
   c) seismology, biology, and cryptology.
   d) seismology, biology, and cosmetology.
   e) the primordial solar nebula composition, extinct marine invertebrates, and
       undesirable activities.

SUGGESTED ANSWER: (a) Getting the right answer may depend mostly
on the reading, not the lectures.

Wrong answers:
b) Biology hasn’t really played much of a role.
c) Cryptology is the study of crypts.
d) Oddly cosmology and cosmetics derive from the same Greek kosmos that originally meant an adornment, particularly to beautiful orderliness (Fu-59–60).
e) Well, no.

Redaction: Jeffery, 2001 Jan 01

021 qmult 00450 2 4 2 moderate deducto-memory: crust composition
66. The composition of the Earth’s crust is dominated by:
   a) oxygen (O) and uranium (U) in about a 1 to 1 ratio by mass.
   b) oxygen (O) and silicon (Si) in about a 2 to 1 ratio by mass.
   c) oxygen (O) and iron (Fe) in about a 1 to 1 ratio by mass.
   d) oxygen (O) and hydrogen (H) in about an 8 to 1 ratio by mass.
   e) argon (Ar) and kryptonite (Ke) in about a 3 to 2 ratio by mass.

SUGGESTED ANSWER: (b) Silicates are mostly SiO₂ (silica) which is not a molecule but simply a compound that forms in different crystal arrangements. The atomic mass of Si is about 28 and of O is about 16. Evidently, the crust is a bit more rich in O than the SiO₂ formula suggests.

Wrong answers:
   a) The surface isn’t that radioactive.
   c) No the crust is not mostly rust which also has hydrogen in it.
   d) No the crust is not mostly water either in liquid or solid form.
   e) Kryptonite! Superman beware.

Redaction: Jeffery, 2001 Jan 01

021 qmult 00600 1 4 4 easy deducto-memory: plate tectonics driver
67. Plate tectonics is driven by:
   a) magnetic fields.  b) the solar wind.  c) comet impacts.
   d) convective heat flow in the mantle.  e) convective heat flow in the atmosphere.

SUGGESTED ANSWER: (d)

Wrong answers:
   c) Not very likely is it.

Redaction: Jeffery, 2001 Jan 01

021 qmult 00710 1 4 1 easy deducto-memory: tectonic plate boundaries
68. Most tectonic plate boundaries are under the ocean, but a few cross land: e.g.,
   a) across Iceland (the Mid-Atlantic Ridge) and southern California from the Gulf of California to about San Francisco (the San Andreas Fault).
b) across Iceland (the Mid-Pacific Ridge) and southern California from the Gulf of California to about San Francisco (the San Fernando Fault).

c) across Nevada (the Las Vegas Wash) and northern California from San Francisco to the Klamath River Valley (the Sonoma Fault).

d) across Nevada (the Las Vegas Wash Basin) and northern California from San Francisco to the Klamath River Valley (the Sonoma Default).

e) across Nevada (the Mifault) and northern California from San Francisco to the Klamath River Valley (the Yur fault).

**SUGGESTED ANSWER:** (a)

**Wrong answers:**

e) Mifault, yur fault—ha, ha, ha, good one eh.

**Redaction:** Jeffery, 2001 jan01

021 qmulf 01110 1 4 2 easy deducto-memory: Pangaea

69. In the Peruvian period about 250 million years ago, the Earth is believed to have had one large super-continent called:

a) Panama.   b) Pangaea.   c) Pangloss.   d) Pan-Am.   e) Panic.

**SUGGESTED ANSWER:** (b) WB-92 says 300 to 250 million years ago and other sources say 225 million years ago. Obviously some discussion is going on. It was a long time ago anyway.

**Wrong answers:**

c) Candide’s tutor, Dr. Pangloss: “This is the best of all possible worlds.”

**Redaction:** Jeffery, 2001 jan01

021 qmulf 01210 1 4 5 easy deducto-memory: trace gas carbon dioxide

70. “Let’s play Jeopardy! For $100, the answer is: This gas is a trace gas in the present-day Earth atmosphere, but its importance for the biosphere both in photosynthesis and as a greenhouse gas is immense.”

What is ___________, Alex?

a) molecular oxygen (O2)   b) helium (H)   c) ozone (O3)   d) argon (Ar)   e) carbon dioxide (CO2)

**SUGGESTED ANSWER:** (e)

**Wrong answers:**

a) Oxygen gas is a product of photosynthesis and I believe plants do need it for respiration, but it is not an important greenhouse gas it seems (SWT-507).

d) Argon is 1.29% by mass and is the 3rd most abundant gas in the atmosphere. But Argon is a noble gas and is chemically almost completely inert.

**Redaction:** Jeffery, 2001 jan01

021 qmulf 01900 1 4 2 easy deducto-memory: greenhouse effect on planets
71. The greenhouse effect is:

a) always disastrous for life.
b) one of the factors that determine the surface temperature of a planet.
c) always good for plants.
d) one of the factors that supposedly determine the surface temperature of a planet.
   The scientific consensus is that it never happens at all.
e) one of the factors that determine the surface temperature of Sun.

SUGGESTED ANSWER: (b) The only thing that may make it hard is if someone confuses the greenhouse effect with the anthropogenic increase in the Earth’s greenhouse effect that is currently under debate. When speaking loosely the later is just called the former, but I think allowed answers preclude confusion.

Wrong answers:
b) As discussed in class we need some and Seeds makes this point briefly.
c) Why should it be?
d) The consensus view is that it does happen. This should be clear from the lectures. Seeds, and even general knowledge.
e) Just to see who’s been on Mars for the last 30 years.

Redaction: Jeffery, 2001 Jan 01

021 qmult 03000 2 4 3 moderate deducto-memory: Earth’s permanent atmosphere

72. In the most current understanding, what is the source of the Earth’s original permanent atmosphere and its water? The source is:

a) gravitational accumulation of gases directly from the solar nebula.
b) the giant impact that caused the Moon’s formation.
c) outgassing from rock caused by internal-heat-driven geological activity and possibly comet impacts. Recent evidence (circa 1999), however, from Comet Hale-Bopp suggests comets may NOT have been important contributors.
d) biological activity.
e) the solar wind and comets. Recent evidence (circa 1999), however, from Comet Hale-Bopp suggests comets may NOT have been important contributors.

SUGGESTED ANSWER: (c) Note this question avoids the primeval-secondary atmosphere question that Seeds discusses.

In a sense, the atmosphere is always coming into being and always passing away, and a fortiori this was more true of the early atmosphere when outgassing, comet impacts, and escape to space probably happened much more furiously than at present: “This is my grandfather’s axe: my father replaced the axe head; I’ve replaced the haft.”

Wrong answers:
a) this answer is not the right one for the “permanent” atmosphere. It may be the source for an early atmosphere of gases. See Se-420.
b) a red herring.
c) biological activity certainly has modified the “permanent” atmosphere creating oxygen, but it wasn’t the original source.
e) the solar wind is actually thought to be the cause of extremely weak atmospheres on Mercury and the Moon, but not on Earth. The part about Comet Hale-Bopp is correct, however.

**Redaction:** Jeffery, 2001 jan 01

022 qmult 00120 2 5 2 moderate thinking: Moon’s daytime

73. The mean lunar month (i.e., the period from new moon to new moon) is 29.53059 days. The Moon is synchronously tidally locked to the Earth. How long is the **DAYLIGHT PERIOD** of the Moon’s day at any point on the Moon? **HINT:** A diagram might help.

a) 29.53059 days.  
b) about 14.8 days.  
c) about 29 days.  
d) 12 hours.  
e) about 365.25 days.

**SUGGESTED ANSWER:** (b)

**Wrong answers:**

- d) This is Earth’s average daytime period.
- e) 365.25 is exactly a Julian year.

**Redaction:** Jeffery, 2001 jan 01

022 qmult 00130 2 5 5 moderate thinking: Earth seen from Moon

74. You are standing on the near side of the Moon. How does the Earth’s position in the sky change relative to your local horizon?

a) The Earth moves across sky from eastern to western horizon for a 12 hour period on average and then is below the horizon for another 12 hour period on average. The Earth does show phases that depend on the time of the lunar month.

b) The Earth circles the zenith position every 24 hours.

c) The Earth circles the zenith position every 29.53059 days on average.

d) The Earth zigzags randomly all across the sky.

e) The Earth stays more or less fixed in the sky relative to the local horizon because of the synchronous tidal locking of the Moon to the Earth. The Earth jiggles about a little because of some wobbling of the Moon. The Earth does show phases that depend on the time of the lunar month.

**SUGGESTED ANSWER:** (e) See HI-136.

**Wrong answers:**

- d) On the near side of the Moon, the Earth must always be above the horizon.

**Redaction:** Jeffery, 2001 jan 01

022 qmult 00200 1 1 1 easy memory: tidal force

75. The “tidal force” on a body can be defined as the difference in gravitational on the body along the line from the body to the source of the gravitational force. The tidal “force” tends to:

a) stretch the body along the line to the gravitational source.  
b) cause the body to collapse.  
c) stretch the body perpendicular to the line to the
gravitational source. d) cause the body to rotate. e) cause the body to splash-down.

**SUGGESTED ANSWER:** (a) A long preamble, but basically an easy memory question both from the course and other sources. I'm not sure there is any strict definition of the tidal force. One always means the varying effect of gravitational field on a body when one invokes it.

**Wrong answers:**
e) A nonsense answer.

**Redaction:** Jeffery, 2001 Jan01

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022 qmult 00210 2 4 2 moderate deducto-memory: two-Moon-Earth facts

76. Two immediately striking facts about the Moon in comparison to the Earth are (1) the Moon's radius is about _______ times the Earth's radius and (2) the Moon's mean density is about _______ times the Earth mean density.

a) 1/4; 2  b) 1/4; 3/5  c) 1/2; 2  d) 2; 2  e) 1/10; 1/20

**SUGGESTED ANSWER:** (b)

**Wrong answers:**
e) Both values are way too small.

**Redaction:** Jeffery, 2001 Jan01

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022 qmult 00225 2 5 3 moderate thinking: Moon's gravity

77. The Moon's mass is about 1/80 of the Earth's mass. But the Moon's surface gravity is about 1/6 of the Earth's surface gravity. Why isn't the Moon's surface gravity about 1/80 of the Earth's surface gravity?

a) The gravitational force of the Earth increases the downward gravitational force on the Moon.
b) The gravitational force law has mass **TIMES** radius squared. The Moon has a small mass relative to Earth, but also a small radius relative to Earth. The two differences cancel somewhat, and so the Moon's surface gravity is not as small as just considering the Moon mass only suggests.
c) The gravitational force law has mass **DIVided** by radius squared. The Moon has a small mass relative to Earth, but also a small radius relative to Earth. The two differences cancel somewhat, and so the Moon's surface gravity is not as small as just considering the Moon mass only suggests.
d) Magnetic fields on the Moon increase the effect of gravity.
e) The astronauts were too full of turkey.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**
a) Certainly the Earth's gravitational force effects the Moon. But this force causes the Moon and things on its surface to fall toward the Earth not to the
center of the Moon. Since the Moon and the things on its surface are falling
toward the Earth, they are in free-fall and weightless relative to the Earth.
b) This could be seen to be wrong simply by recalling the gravitational force
law. But it can also be deduced to be wrong. If it were mass times radius
squared, then small mass and small radius would result in smaller surface
gravity than 1/60 of Earth’s.
d) A red herring. The Moon doesn’t have much magnetic field anyway.
e) This is the Thanksgiving answer. It doesn’t work in the spring term.

Redaction: Jeffery, 2001 Jan 01

022 qmult 00230 1 1 3 easy memory: far side of the Moon
78. The far side of the Moon is:
   a) seen from Earth once per month.  b) seen from Earth only at new moon.
c) never seen from Earth.  d) seen from Earth only during solar eclipses.
e) constantly visible from Earth.

SUGGESTED ANSWER: (c)

Wrong answers:
e) Exactly wrong.

Redaction: Jeffery, 2001 Jan 01

022 qmult 00240 1 4 1 easy deducto-memory: lunar sky
79. The sky on the Moon is always:
   a) black.  b) blue.  c) red.  d) red and white.  e) red, white, and
   blue.

SUGGESTED ANSWER: (a) The Moon has virtually no atmosphere. Hence
the light from astronomical sources will not be scattered about. The surface is
brightly illuminated during the day, but the sky still looks black and stars can
be seen???. Well maybe not. They are as bright as at night, but eyes or cameras
adjusted to bright conditions may not be able to see them.

Wrong answers:
b) Nah, nah, that’s the Earth.
c) True the Soviets did send the first probes around the Moon and to its surface.
d) Canada has no lunar specialties.
e) “Hurrah for the red, white, and blue, da da dada, da da dada”—John Philip
Sousa forever.

Redaction: Jeffery, 2001 Jan 01

022 qmult 00260 1 1 1 easy memory: Moon has no atmosphere
80. The Moon has:
   a) almost no atmosphere.
b) a thick, dry, carbon dioxide atmosphere.
c) a water vapor atmosphere which is thick enough to cause clouds that are sometimes seen from Earth.

d) a thin, but nearly breathable, oxygen-nitrogen atmosphere.

e) a thick atmosphere of nearly transparent molecular hydrogen gas.

**SUGGESTED ANSWER:** (a) Well the longest-answer-is-the-right-answer rule fails here. Everyone who has read the book, been to the lectures, or has reasonable general knowledge knows the Moon is almost airless. It can't be said to be completely airless, because an extremely tenuous atmosphere does exist, that has practically no effect on anything.

**Wrong answers:**

e) The solar wind seems to provide some H\textsubscript{2}, but there isn't a lot of it.

**Redaction:** Jeffery, 2001 jan01

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81. A mare (Latin for “sea”: the last “e” is not silent, but the pronunciation seems various and who knows how the Romans really said it: plural “maria”) is:

a) a region of the light colored lunar highlands.

b) a dark lava plain on the Moon that is **LIGHTLY** cratered compared to the lighter colored lunar highlands.

c) a dark lava plain on the Moon that is **HEAVILY** cratered compared to the lighter colored lunar highlands.

d) a sea bed of a dried up lunar sea.

e) the mother of a colt.

**SUGGESTED ANSWER:** (b) Sea bed or seabed? Barnhart (Ba-1092) fails me.

**Wrong answers:**

e) Not the best answer in the context of this course or this question.

**Redaction:** Jeffery, 2001 jan01

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82. A moonquake is:

a) a wobble of the Moon in its orbit.  b) a lunar mare.  c) a fluctuation in the Moon’s reflected brightness caused by a strong gust of the solar wind.  d) the Moon’s equivalent of an earthquake.  e) a contradiction in terms.

**SUGGESTED ANSWER:** (d)

**Wrong answers:**

e) No its not. A Moon earthquake is a contradiction in terms.

**Redaction:** Jeffery, 2001 jan01

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83. A moonquake is:

a) a wobble of the Moon in its orbit.  b) a lunar mare.  c) a fluctuation in the Moon’s reflected brightness caused by a strong gust of the solar wind.  d) the Moon’s equivalent of an earthquake.  e) a contradiction in terms.

**SUGGESTED ANSWER:** (d)

**Wrong answers:**

e) No its not. A Moon earthquake is a contradiction in terms.

**Redaction:** Jeffery, 2001 jan01
83. The current favored theory for the formation of the Moon is the:

   a) co-accretion theory.  b) tidal coupling theory.  c) capture theory.
   d) fission theory.  e) giant impactor theory.

SUGGESTED ANSWER: (e)

Wrong answers:
   c) The capture idea seems dynamically unlikely to those who know how celestial
mechanics go.

Redaction: Jeffery, 2001 Jan 01

022 qmult 00800 3 1 3 hard memory: giant impactor formation of Moon

84. The giant impactor theory of the Moon’s formation explains:

   a) the heavy cratering of the Moon, the lunar maria, and the inclination of the
   Earth’s axis.
   b) the relatively low uncompressed mean density of the Moon compared to that of
   the Earth and the existence of the lunar maria.
   c) the relatively low uncompressed mean density of the Moon compared to that of
   the Earth and the similar composition of the Earth and lunar crusts and mantles.
   d) the relatively low uncompressed mean density of the Moon compared to that of
   the Earth and the length of the lunar month.
   e) the heavy cratering of the Moon, the lunar maria, and the chemical differentiation
   of the lunar material.

SUGGESTED ANSWER: (c) See Se-418 for estimated uncompressed densities. The uncompressed densities are a more direct measure of the composition. I think the uncompressed densities can be estimated without specifying the composition to fully and so using them isn’t entirely circular.

Wrong answers:
   e) These is explained by the heavy bombardment and the internal heat of the
   Moon.

Redaction: Jeffery, 2001 Jan 01

022 qmult 01200 2 1 4 moderate memory: regolith

85. Lunar regolith is:

   a) lunar rock ground down to fragments and dust by volcanic action.
   b) lunar rock ground down to fragments and dust by strong winds present on the
   early Moon.
   c) lunar rock ground down to fragments and dust by the solar wind.
   d) lunar rock ground down to fragments by meteoric impacts, and on the surface
   few meters to dust. The dust is due mainly to the sandblasting effects of
   micrometeorites.
   e) lightly cratered lunar terrain.
SUGGESTED ANSWER: (d) But I think the answer is deduceable too at least from the longest-answer-is-the-right-answer rule. Se-452, none too clearly, says the regolith is the dust or lunar soil, not the larger fragments. The other books, even Lewis, p. 386 are equivocal. See HI-142.

Wrong answers:
- a) Volcanic action has long stopped on the Moon. Sometimes it creates soot powder though I think.
- b) Maybe plausible, but no one has talked about strong lunar winds.
- c) The Solar wind is atomic. I don’t think it can pulverize.
- e) This may sound plausible.

Redaction: Jeffery, 2001jan01

022 qmult 01210 2 4 5 moderate deducto-memory: lunar sedimentary rock
86. The percentage of lunar surface rock that is SEDIMENTARY is:
   - a) 90%.
   - b) about 60%.
   - c) 20%.
   - d) about 10% as far as we know.
   - e) zero as far as we know.

SUGGESTED ANSWER: (e) The Moon has never had significant water geology as far as we can tell. All rock is igneous or metamorphic.

Wrong answers:
- d) Sounds sort of plausible doesn’t it.

Redaction: Jeffery, 2001jan01

022 qmult 01310 2 4 1 moderate deducto-memory: roundness and cratering
87. Until about the middle of the 20th century most geologists thought the lunar craters were mostly volcanic. This was so because it was thought that impact craters:
   - a) could not be mostly so round as almost all lunar craters appeared to be.
   - b) had to be mostly so round as almost all lunar craters appeared to be.
   - c) could not be on top of mountains as almost all lunar craters appeared to be.
   - d) had to be on top of mountains as almost all lunar craters appeared to be.
   - e) had to be squarish unlike lunar craters.

SUGGESTED ANSWER: (a) A somewhat convoluted sentence, but it works. See FMW-173

Wrong answers:
- b) This answer gives a fact that contradicts the conclusion it was meant to prove. No doubt Aristotle has a name for this logical fallacy.

Redaction: Jeffery, 2001jan01

022 qmult 01500 2 4 4 moderate deducto-memory: last humans on the Moon
88. Astronauts last went to the Moon in:
   - b) 1984.
   - c) 1958.
   - d) 1972.
   - e) 1948.
SUGGESTED ANSWER: (d) A moderate deducto-memory question, except for those students who regard the lunar landings in the same category Lindbergh’s trans-Atlantic solo flight: i.e., one with Nineveh and Tyre.

Wrong answers:
c) Great year. Superb vintage and all that.

Redaction: Jeffery, 2001 Jan 01

023 qmult 00200 1 4 3 easy deducto-memory: Mercury’s distance from Sun
89. The mean distance of Mercury from the Sun is:
   a) 1.52 astronomical units.  b) 1 astronomical unit.  c) 0.39 astronomical units.  d) 39.5 astronomical units.  e) 0.97 astronomical units.

SUGGESTED ANSWER: (c) An easy deduction question once astronomical unit is recalled.

Wrong answers:
b) This is the mean distance of the Earth.

Redaction: Jeffery, 2001 Jan 01

023 qmult 00210 1 4 2 easy deducto-memory: Mercury’s size
90. Among the rocky (or terrestrial) planets, Mercury is:
   a) largest.  b) smallest.  c) most massive.  d) farthest from the Sun.
   e) reddest.

SUGGESTED ANSWER: (b) I think Pluto must be counted as an icy-rocky body, not a rocky body.

Wrong answers:
e) Mars is reddest by most standards.

Redaction: Jeffery, 2001 Jan 01

023 qmult 00230 1 4 5 easy deducto-memory: Mariner 10 to Mercury
91. “Let’s play Jeopardy! For $100, the answer is: It is the only probe to have obtained close-up images of Mercury through year 2004.”

What is __________, Alex?
   a) Apollo 11  b) the Jupiter 2  c) the Enterprise  d) Santa 6  e) Mariner 10

SUGGESTED ANSWER: (e)

Wrong answers:
b) You all remember Lost in Space: they don’t make TV shows like that any more.
d) The Christmas answer.
Redaction: Jeffery, 2001Jan01

023 qmult 00250 2 5 2 moderate thinking: Mercurian day
92. The ratio of Mercury’s rotation period (period for one axis rotation) to its revolution period (period for one orbit around the Sun) is 2/3. Both these periods are relative to the fixed stars and both are counterclockwise when view from the north ecliptic pole. How long is Mercury’s day (i.e., noon to noon period) in units of its revolution period? HINT: An orbital diagram with artificial mountain on Mercury might help.

a) 1 revolution period. b) 2 revolution periods. c) 3 revolution periods. d) 1/2 revolution period. e) 1/3 revolution period.

SUGGESTED ANSWER: (b)

Wrong answers:
a) This would be true with synchronous tidal locking, but Mercury is nonsynchronously tidally locked to the Sun.

Redaction: Jeffery, 2001Jan01

023 qmult 00300 2 4 3 moderate deducto-memory: Mercury’s iron content
93. Based on the theory of planet formation we would expect Mercury to be richer in RELATIVE iron abundance than:
a) Jupiter, but not Earth. b) icy planetesimals, but not Earth. c) Earth. d) Earth, but not the Sun. e) Mars, but not the Sun.

SUGGESTED ANSWER: (c) The students have to have caught that there will be a higher ratio of metallic matter to rocky the closer the formation was to the Sun. But Se-462 says this effect may be insufficient to explain just how rich Mercury is in iron. Maybe a giant impactor knocked off much of the silicate-rich mantle after Mercury formed.

Wrong answers:
e) The Sun is very low in iron abundance because its huge abundances of hydrogen and helium.

Redaction: Jeffery, 2001Jan01

023 qmult 00410 1 4 1 easy deducto-memory: Mercury’s lava plains
94. Mercury has lava plains somewhat like the Moon’s maria, but these Mercurian plains:
a) are not so dark and noticeable. b) cover all the Mercurian impact craters. c) are very much darker than the lunar maria. d) are green. e) are green because they are covered with vegetation.

SUGGESTED ANSWER: (a) See Se-460–461.

Wrong answers:
e) Mercury is barren.

Redaction: Jeffery, 2001Jan01
023 qmult 00600 2 4 4 moderate deducto-memory: Mercury’s lobate scarps
95. Features found on Mercury, but NOT on the Moon, are:
   a) giant lava-flooded impact basins such as the Orientale Basin.  
   b) geysers.  
   c) impact craters of tens of kilometers in diameter.  
   d) lobate scarps that can stretch over hundreds of kilometers.  
   e) volcanic craters.

SUGGESTED ANSWER: (d)

Wrong answers:
   a) The Orientale Basin is on the Moon, but it is a giant lava-flooded impact basin. The Caloris Basin is a giant lava-flooded impact basin on Mercury.

Redaction: Jeffery, 2001 jan01

024 qmult 00010 1 4 2 easy deducto-memory: Venus radius
96. Venus’ radius is:
   a) 0.01 Earth radii.  
   b) 0.95 Earth radii.  
   c) 11.2 Earth radii.  
   d) 100.2 Earth radii.  
   e) 0.7233 AU.

SUGGESTED ANSWER: (b) The exact number no one remembers, but everyone should remember that Venus is just a bit smaller than the Earth.

Wrong answers:
   c) This is Jupiter’s radius.  
   e) This is Venus’ mean distance from the Sun.

Redaction: Jeffery, 2001 jan01

024 qmult 00020 2 4 3 moderate deducto-memory: Venus rotation
97. The period for Venus’ axial rotation relative to fixed stars is unusually long for planet (243.0187 days) and the rotation is retrograde (i.e., clockwise as viewed from the north ecliptic pole) which is unlike most of the other planets. These unusual rotation characteristics may be due to:

   c) a SMALL impactor that randomly altered the rotation characteristic imposed at formation. Those formation characteristics may have been more like those of Earth and Mars.

   b) SYNCHRONOUS TIDAL LOCKING to the Sun. Recall the Venusian year (i.e., revolution period) relative to the fixed stars is 224.695 days.

   c) a GIANT impactor that randomly altered the rotation characteristic imposed at formation. Those formation characteristics may have been more like those of Earth and Mars.

   d) NON-SYNCHRONOUS TIDAL LOCKING to the Sun exactly like the tidal locking of Mercury to the Sun. Recall that the ratio of the Mercurian rotation period to Mercurian revolution period is 2/3 nearly exactly.

   e) a gravitational perturbation by Jupiter.

SUGGESTED ANSWER: (c) Pure deduction works here if one is really clever,
but impure deduction plus a bit of memory should make this question not too hard.

Wrong answers:
  a) Now a small impactor wouldn’t do very much now would it.
  b) The answer clearly contradicts itself in that the revolution period is not equal to the rotation period.
  d) Well the 243.0187/224.695 is not 2/3. Of course, since answer (b) was a wrong answer, then one doesn’t have to believe 224.695 days is the Venusian year really: but actually it is. Still one can deduce this answer is wrong because if it were right the Venusian year would have to be about 365 days which is the about Earth’s year and we know Venus can’t have a year like that since it is much closer to the Sun than the Earth.
  e) Now Jupiter’s gravity does a lot of things, but why would it cause Venus to act funnily and not Earth and Mars in respect to rotation.

Redaction: Jeffery, 2001 jan01

024 qmult 00200 1 4 3 easy deducto-memory: Venus surface temperature
98. The surface of temperature of Venus is about:
   a) 273.15 K.   b) 15 K.   c) 740 K.   d) 15 \times 10^6 K.   e) 20° C.

SUGGESTED ANSWER: (c) An easy look-up or deduction question. We know Venus is hot compared to the Earth, but it’s not a solar inferno.

Wrong answers:
  a) This is the freezing temperature of water.
  b) This is really cold.
  d) This is about the central temperature of the Sun (Sc-243).
  e) Room temperature.

Redaction: Jeffery, 2001 jan01

024 qmult 00220 2 1 2 moderate memory: Venus seasons
99. Venus has virtually no seasons because:
   a) of SMALL eccentricity and axis inclination, and HIGHLY VARIABLE, heat-transport-INEFFICIENT global atmospheric circulation.
   b) of SMALL eccentricity and axis inclination, and HIGHLY STABLE, heat-transport-EFFICIENT global atmospheric circulation.
   c) Venus is CLOSER TO the Sun than Earth.
   d) of LARGE eccentricity and axis inclination, and HIGHLY STABLE, heat-transport-EFFICIENT global atmospheric circulation.
   e) Venus is FARTHER FROM the Sun than Earth.

SUGGESTED ANSWER: (b)

Wrong answers:
  a) The atmospheric circulation is very stable and efficient.
  c) Irrelevant.
d) Eccentricity and axis inclination are small: the converse leads to season.
e) Irrelevant and wrong.

Redaction: Jeffery, 2001jan01

024 qmult 00300 1 1 2 easy memory: Venus atmosphere
100. Venus has a:

a) THICK, carbon-dioxide-RICH atmosphere, and so has virtually NO greenhouse effect.
b) THICK, carbon-dioxide-RICH atmosphere, and so has an EXTREME greenhouse effect.
c) THIN, carbon-dioxide-POOR atmosphere, and so has an EXTREME greenhouse effect.
d) THIN, carbon-dioxide-POOR atmosphere, and so has virtually NO greenhouse effect.
e) THICK carbon-dioxide-POOR atmosphere, and so has a REVERSE greenhouse effect: i.e., the surface is cooled far below what it would be if there were no atmosphere at all.

SUGGESTED ANSWER: (b)

Wrong answers:
a) Carbon dioxide is a strong greenhouse gas.
c) Venus atmosphere is 96 per cent CO₂ and is 90 Earth pressures.
d) See (a) and (c).
e) I suppose an atmosphere that resisted radiation flowing in more than flowing out would be cause a reverse greenhouse effect. I don’t know if any such atmosphere has been seen in nature. A perfectly reflecting atmosphere, would mean the surface would be absolute zero aside from internal heating.

Redaction: Jeffery, 2001jan01

024 qmult 00310 2 4 5 moderate deducto-memory: Venus illumination
101. The daytime illumination on the surface of Venus is __________, because the ________ light is strongly absorbed by the thick ________-dominated atmosphere.

   a) bluish; reddish; CO₂   b) bluish; reddish; N₂   c) orangy; bluish; water-vapor   d) orangy; bluish; N₂   e) orangy; bluish; CO₂

SUGGESTED ANSWER: (e) See FMW-194 and Se-475. FMW-194 is specific about the absorption. But neither says it is the CO₂ that does the absorbing, but the right answer doesn’t imply that CO₂ that does necessarily.

Wrong answers:
c) There is some water vapor in the Venusian atmosphere, but not a lot (Se-467).

Redaction: Jeffery, 2001jan01
024 qmult 00320 2 4 2 moderate deducto-memory: Venus not red hot
102. The surface of Venus is very hot (i.e., about 470°C or 740 K). To the human eye, it is:
  a) obviously red hot.  b) not quite red hot at least not obviously so. Red hotness begins at about 500°C.  c) blue hot.  d) still many hundreds of
degrees celsius below the temperature for being red hot.  e) X-ray hot.

SUGGESTED ANSWER: (b) Sources say Venus should not quite be red hot. But I wonder if to the sensitive human eye it might not glow reddish just a little
in dark conditions.

For red hot conditions, see The Physics Factbook at

Wrong answers:
  e) As Lurch would say: “Aaaaarh.”

Redaction: Jeffery, 2001 jan01

024 qmult 00500 2 4 1 moderate deducto-memory: Venus geological processes
103. Venus has:
  a) NO liquid water erosion, NO micrometeoritic erosion, and NO evidence of
full plate tectonics. Geological activity is mainly volcanic and tectonic due to
INTERNAL HEAT with some wind erosion. But large-scale impactor geology
(i.e., impactor cratering) is more important on Venus than on Earth because of
the low level of erosion compared to the Earth and, perhaps, because of a lower
level of internal-heat-driven geology.
  b) NO liquid water erosion, NO micrometeoritic erosion, and NO evidence of
full plate tectonics. There is NO INTERNAL-HEAT-DRIVEN geological
activity at all. There is probably some solar tidal force geological activity and
large impactors occasionally hit. Like the Moon and Mercury, Venus is nearly a
dead world.
  c) liquid water erosion, micrometeoritic erosion, and full plate tectonics. There
is also INTERNAL-HEAT-DRIVEN geological activity. Except for the
micrometeoritic erosion, Venus geology is MUCH like the Earth’s.
  d) liquid water erosion, micrometeoritic erosion, and full plate tectonics. There
is also INTERNAL-HEAT-DRIVEN geological activity. Venus geology is
EXACTLY like the Earth’s.
  e) no impact craters.

SUGGESTED ANSWER: (a)

Wrong answers:
  b) Since Venus is nearly the same size and density as the Earth internal-heat-
driven geology should occur.
  c) There is no liquid water on Venus (except maybe for drops high in the
atmosphere): the lower atmosphere is very dry. The thick atmosphere
burns up most small meteors, and so no significant micrometeoritic erosion
is expected.
  d) See (c)
e) There are. Because of the low level of erosion compared to the Earth, there are many more large impact craters on Venus than on Earth.

Redaction: Jeffery, 2001jan01

024 qmult 00600 2 4 2 moderate deducto-memory: Venus and Earth similar?

104. Why might one expect Venus and Earth to be similar?

a) They are nearly at the same distance from the Sun.

b) They have nearly the same mass and mean density, and the difference in their distances from the Sun isn’t huge.

c) Because Venus is closer to the Sun than Earth.

d) They have nearly the same color.

e) They have nearly the same rotation period relative to the Sun (i.e., day period).

SUGGESTED ANSWER: (b)

Wrong answers:

a) Well they aren’t all that close together.

c) A red herring.

d) No they don’t and if they did it wouldn’t necessarily mean anything.

e) No they don’t and if they did it wouldn’t necessarily mean anything.

Redaction: Jeffery, 2001jan01

024 qmult 00620 2 4 2 moderate deducto-memory: Ishtar and Aphrodite

105. The Ishtar and Aphrodite are:

a) Venusian impact craters.  b) Venussian terras.  c) Martian impact craters.  d) Martian volcanoes.  e) dear friends of Santa.

SUGGESTED ANSWER: (b)

Wrong answers:

e) I’m sure that Santa is very fond of the two love goddesses—even if they have been naughty.

Redaction: Jeffery, 2001jan01

024 qmult 00800 2 4 4 moderate deducto-memory: shield volcano

106. Shield volcanoes such ones finds on Venus, Earth, and Mars have slopes that:

a) rise very steeply.  b) fall-off quickly into volcanic depressions.  c) rise very steeply and are topped by impact craters.  d) rise at very low angle (i.e., a low grade).  e) fall-off quickly into a salt-water lake.

SUGGESTED ANSWER: (d)

Wrong answers:

c) It’s not likely that every shield volcano has an impact crater on top.

Redaction: Jeffery, 2001jan01
024 qmult 00900 1 4 4 easy deducto-memory: Venus corona

Extra keywords: CM-168–169

107. “Let’s play Jeopardy! For $100, the answer is: These geological features on Venus consist of raised or depressed roughly circular regions with circular and radial fractures; they have volcanoes on them and are sometimes flooded with lava. They are probably due to rising mantle plumes of magma.”

What are ____________, Alex?

a) terras     b) maria     c) tectonic plates     d) coronas     e) moons

SUGGESTED ANSWER: (d)

Wrong answers:
  a) Terras are extended upland and not circular.
  b) The term “mare” is used only for the Moon and maria aren’t like coronas.

Redaction: Jeffery, 2001 jan01

024 qmult 01100 1 4 3 easy deducto-memory: fate of Venus

108. The final fate of Venus is probably to:

a) collide with the Earth.
  b) collide with Mars.
  c) be evaporated in the Sun during a red giant phase in about 7 Gyr.
  d) be evaporated in the Sun during a red giant phase in 7 million years.
  e) be left as cold rocky world with a cold CO₂ atmosphere and no internal heat. A layer of CO₂ ice might condence out on the surface. This will happen billions of years from now after the Sun has become a white dwarf star.

SUGGESTED ANSWER: (c) See FK-493 for the 7 Gyr value.

Wrong answers:
  e) If the Sun doesn’t evaporate Venus, something like this may happen to it.

Redaction: Jeffery, 2001 jan01

025 qmult 00100 1 4 1 easy deducto-memory: Mars’ order from Sun

109. Going outward from the Sun, Mars is the:

a) 4th planet.     b) 3rd planet.     c) 10th planet.     d) 1st planet.
  e) 3rd and 5th planet.

SUGGESTED ANSWER: (a)

Wrong answers:
  b) This is Earth. Y’know: third rock from the Sun.
  c) This is the undiscovered planet X.
  d) This is Mercury.
  e) Note even possible without some special assumptions.

Redaction: Jeffery, 2001 jan01
025 qmult 00200 1 4 5 easy deducto-memory: Mars’ discovery

110. Mars was discovered in:
   
   a) 1610 by Galileo Galilei (1564–1642).  
   b) 1655 by Christian Huygens (1629–1695).  
   c) 1869 by Pietro Angelo Secchi (1818–1878).  
   d) 1877 by Giovanni Schiaparelli (1835–1910).  
   e) in prehistory by numerous persons
   no doubt.

SUGGESTED ANSWER: (e)

See
http://www.uapress.arizona.edu/online.bks/mars/contents.htm for the
history of the observation of Mars.

Wrong answers:
   
   a) Galileo in 1610 may have been the first to view Mars telescopically.
   b) 1655 was the first time Huygens observed Mars telescopically.
   c) Secchi introduced the Italian word *canale* for narrow features he saw on Mars
   in 1869. It was Schiaparelli who really pushed for the existence and made
   them widely known.
   d) In 1877, Mars was in perihelion oposition and Schiaparelli’s observations of
   that year led him to introduce widely the idea of Martian canals.

Redaction: Jeffery, 2001 jan01

025 qmult 00310 1 4 2 easy deducto-memory: Martian seasons

111. Mars has seasons principally because:
   
   a) it is red.  
   b) its axis is tilted by about 25° to the pole perpendicular to
   Mars’s orbital plane.  
   c) its orbit is super-highly elliptical.  
   d) of its volcanoes.  
   e) of its impact craters.

SUGGESTED ANSWER: (b) Well Ka-291 and PF-117 states that the tilt is
the main cause of the seasons. I think the fairly large eccentricity of Mars’ orbit
must play a secondary role.

Wrong answers:

a) A red herring.

b) Well Mars eccentricity is 0.0934 which is pretty large for a planet, but you
   still can’t say its orbit is super-highly elliptical.

b) Nah.

e) Nah.

Redaction: Jeffery, 2001 jan01

025 qmult 00312 1 4 4 easy deducto-memory: Mars size

112. The Mars’ diameter in units of Earth’s diameter is about:
   
   a) 10.  
   b) 5.  
   c) 1.  
   d) 1/2.  
   e) 1/1000.
SUGGESTED ANSWER: (d) The accurate value is 0.5326 for equatorial diameters.

Wrong answers:
  a) Everyone should know Mars is significantly smaller than Earth.
  e) But Mars is not tiny compared to Earth.

Redaction: Jeffery, 2001 Jan 01

025 qmult 00400 1 4 4 easy deducto-memory: largest Martian volcano
113. The largest volcano on Mars and perhaps in the solar system is:

   a) Valles Marineris.   b) Phobos.   c) Ishtar Terra.   d) Olympus Mons.
   e) Kitt Peak.

SUGGESTED ANSWER: (d) See FMW-197.

Wrong answers:
  a) This is the big crack canyon on Mars.
  b) This is the larger Martian moon.
  c) This is a highland region on Venus. See Se-471
  e) This is the site of the National Optical Astrophysical Observatories’ (NOAO)
     North American observatory. It’s in Arizona, south-west of Tucson.

Redaction: Jeffery, 2001 Jan 01

025 qmult 00500 1 4 4 easy deducto-memory: Valles Marineris
114. Valles Marineris is a:

   a) Hibernian bog.
   b) small valley on Venus.
   c) small valley on Mars that was probably formed by a huge river, now of course
      completely dry.
   d) large valley on Mars that was probably formed by the Martian crust cracking and
      subsiding somehow.
   e) large valley on Mars that was probably formed by a long drought early in Martian
      history.

SUGGESTED ANSWER: (d) See FMW-198, Se-483. Valles Marineris was
named for one or more of the Mariner probes, but I can’t find a reference for this.

Wrong answers:
  a) An Irish swamp. I ought to know since I may already be Irish myself.
  b) It’s on Mars.
  c) Just a fact: people don’t think Valles Marineris was primarily formed by
     water although water may have played a role in shaping the canyon (FMW-198).
  e) Droughts don’t make valleys. Yes, no, maybe, probably, certainly, without a
     doubt, positively, nah.

Redaction: Jeffery, 2001 Jan 01
025 qmult 00600 1 1 3 easy memory: Mars and Venus different atmospheres
115. Venus and Mars have atmospheres which are 96% and 95% carbon dioxide (CO₂) by
to number, respectively. So why are the Venus and Mars atmospheres so different?

a) Venus’ atmosphere has **SULFURIC ACID DROPLET CLOUDS** and Mars’
atmosphere has clouds of **GREEN** dust.
b) Venus has no moons and almost no inclination of its rotation axis from the
ecliptic pole. Mars has two moons and an axis inclination of about 25° from
the perpendicular pole to its orbit.
c) The surface pressure of Venus is **ABOUT 90** times Earth’s surface pressure:
Mars’ surface pressure is about a **HUNDRETH** of Earth’s surface pressure.
Thus, the CO₂ atmosphere of **VENUS** is much, much thicker than that of Mars.
d) The surface pressure of Venus is **ABOUT 1/90** times Earth’s surface pressure:
Mars’ surface pressure is about a **HUNDRED TIMES** Earth’s surface pressure.
Thus, the CO₂ atmosphere of **MARS** is much, much thicker than that of
**VENUS**.
e) The surface pressure of Venus is about the **SAME** as Earth’s surface pressure:
Mars’ surface pressure is about a **HUNDRETH** of Earth’s surface pressure.
Thus, the CO₂ atmosphere of **VENUS** is much, much thicker than that of
**MARS**.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**
a) Not highly relevant and Mars has red dust clouds.
b) Not highly relevant.
d) Wrong way around on the numbers.
e) One has to remember that Venus’s atmosphere is much thicker than Earth’s.

**Redaction:** Jeffery, 2001jan01

025 qmult 00830 2 1 3 moderate memory: rain-fed run-off channels
116. Circa 2003, analysis of dendritic channels on Mars based on Mars Global Surveyor data
led to the conclusion that in some cases at least these channels were very probably:

a) glacial melt ponds.  b) glacial melt oceans.  c) rain-fed run-off
channels.  d) rain-fed canals.  e) snow-fed canals.

**SUGGESTED ANSWER:** (c) See Kerr, R. A. 2003jun06, Science, 300, 1496.

**Wrong answers:**
d) There are no canals on Mars.

**Redaction:** Jeffery, 2001jan01

025 qmult 00900 2 4 5 moderate deducto-memory: Allan Hills 84001
117. “Let’s play *Jeopardy!* For $100, the answer is: NASA researchers in 1996 proposed
that this object possibly contained fossilized Martian microbes.”

What is ____________, Alex?
SUGGESTED ANSWER: (e)

Wrong answers:
d) Good old Cary Grant (1904–1986).

Redaction: Jeffery, 2001 jan01

025 qmult 03300 2 5 3 moderate thinking: Mars' moons tidally locked

118. Mars’ moons Phobos and Deimos are small, nonspherical bodies with triaxial dimensions in kilometers of about $27 \times 21.6 \times 18.8$ and $15 \times 12.2 \times 11$, respectively. Their mean distances from Mars center are 2.761 and 6.906 Mars radii (1.470 and 3.678 Earth radii). Their eccentricities are 0.015 and 0.0005. Their orbital periods and rotational periods are the same length: the periods for Phobos are 0.31891023 days and for Deimos are 1.2624407 days. They both orbit eastward. Because Phobos' orbital period is shorter than Mars' rotational period (1.02595675 days), Phobos rises west and sets east. Deimos rises east and sets west, but moves relatively slowly across the sky relative to a local sky coordinate system. The moons are probably captured asteroids. The exact sameness (on average) of moons' orbital and rotational periods shows that they are tidally locked to Mars. Why would this be expected?

a) Because of the strength of the solar wind.

b) They are close to Mars, and so Mars's tidal force is probably quite STRONG. Moreover, their small size meant that they probably had INCREDIBLY HUGE ROTATIONAL KINETIC ENERGY when they started orbiting Mars. The MORE the initial rotational kinetic energy, the easier it was to get rid of enough of it to have slowed them down to the tidally locked situation. Thus their probably huge initial rotational kinetic energy also helped tidal locking to occur.

c) They are close to Mars, and so Mars's tidal force is probably quite STRONG. Moreover, their small size meant that they probably had LOW ROTATIONAL KINETIC ENERGY when they started orbiting Mars, unless they were rotating incredibly quickly. The LOWER the initial rotational kinetic energy (provided it was greater than needed for tidally locking), the easier it was to get rid of enough of it to have slowed them down to the tidally locked situation. If they had insufficient initial rotational kinetic energy for tidal locking, the Martian tidal force would have had to speed them up; but since they are small bodies, that added amount of rotational kinetic energy was probably relatively small. Thus because of their small size, it was probably relatively easy to change their rotational kinetic energy to just the amount needed for tidal locking.

d) They are close to Mars, and so Mars's tidal force is probably quite WEAK. Moreover, their small size meant that they probably had INCREDIBLY HUGE ROTATIONAL KINETIC ENERGY when they started orbiting Mars. The MORE the initial rotational kinetic energy, the easier it was to get rid of enough of it to have slowed them down to the tidally locked situation. Thus their probably huge initial rotational kinetic energy also helped tidal locking to occur.
e) They are close to Mars, and so Mars’s tidal force is probably quite **WEAK**. Moreover, their small size meant that they probably had **LOW ROTATIONAL KINETIC ENERGY** when they started orbiting Mars, unless they were rotating incredibly quickly. The **LOWER** the initial rotational kinetic energy (provided it was greater than needed for tidally locking), the easier it was to get rid of enough of it to have slowed them down to the tidally locked situation. If they had insufficient initial rotational kinetic energy for tidal locking, the Martian tidal force would have had to speed them up; but since they are small bodies, that added amount of rotational kinetic energy was probably relatively small. Thus because of their small size, it was probably relatively easy to change their rotational kinetic energy to just the amount needed for tidal locking.

**SUGGESTED ANSWER:** (c) Yes, Phobos and Deimos have synchronous orbital and rotational periods (Cox-307). Note the reasoning is all plausible, not conclusive. It’s based on general ideas about how things in the solar system are arranged in terms of relative amounts of rotational kinetic energy and strengths of tidal forces. It wouldn’t take a lot of work though to investigate the problem mathematically, but that is well beyond the scope of this class (and beyond any interest of mine at the moment).

**Wrong answers:**

a) An irrelevant red herring.

b) Nothing rules out huge initial rotational kinetic energy, but it doesn’t seem likely. In any case the larger the rotational kinetic energy, the longer it would take for the tidal force to effect tidal locking.

d) See (b). Also the tidal force is probably quite strong. But really the student doesn’t know this. But the student knows the stronger the tidal force, the easier it is to effect tidal locking. And the question asks why we would expect tidal locking. Actually the tidal force scales as \((M_{\text{central body}}/d^3)r\) (French p. 533). Mars is 1/11 of the Earth Mass, the distance \(d\) to Deimos is about 1/16 of the Earth-Moon distance, and \(r\) (the Deimos radius) is about 1/300 of the Moon’s radius. Thus the tidal force of Mars on Deimos is of order \((1/11)(1/300)/(1/16)^3 = 4000/3300 = 1\) of the Earth’s on the Moon. Since Deimos had very probably much less kinetic energy than the Moon, tidal locking probably happened much faster than in the case of the Moon.

e) See (d)

**Redaction:** Jeffery, 2001

026 qmult 00100 1 4 4 easy deducto-memory: gas giant planets
119. “Let’s play *Jeopardy!* For $100, the answer is: These planets are:

1) massive;
2) powerful gravity sources;
3) comparitely low in density;
4) in outer solar system beyond 5 AU where it is generally pretty cold;
5) have compositions dominated by hydrogen and helium;
6) have extensive moon systems;
7) have complex ring systems.”
What are the __________, Alex?

a) rocky planets    b) Bullwinkle and Rocky    c) Kuiper Belt objects
d) gas giant or Jovian planets    e) gas giant or Jovial planets

**SUGGESTED ANSWER:** (d)

**Wrong answers:**
e) Ho, ho, ho.

**Redaction:** Jeffery, 2001 jan 01

026 qmult 00200 1 1 1 easy memory: gas giant elements
120. 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, 2001 jan 01

026 qmult 00500 2 4 1 moderate deducto-memory: gas giant bands
121. The gas giant planet atmospheres exhibit a band structure because of __________ from their _____ interiors combined with _______ rotation.

a) convection; hot; rapid     b) radiative transport of heat; hot; rapid
c) convection; hot; slow     d) radiative transport of heat; cold; slow
e) radiative transport of heat; cold; slow

**SUGGESTED ANSWER:** (a) See Sh-452, FMW-220, Se-498.

**Wrong answers:**
c) Not slow.

**Redaction:** Jeffery, 2001 jan 01

026 qmult 00800 2 4 3 moderate deducto-memory: ring complexity
122. What is a major reason why the ring systems of the gas giants are so complex with knots and arcs, etc.?

a) The perfectly spherical shapes of the particles.
b) The cubical shapes of the particles.
c) Subtle gravitational perturbations by the gas giant moons.
d) Subtle magnetic perturbations by the gas giant moons.
e) The tenth planet from the Sun, Planet X, gravitationally perturbs the rings.

**SUGGESTED ANSWER:** (c) See HI-211 and SRJ-229.
Wrong answers:
  a) The particle shapes are probably pretty random, but spherical is probably a
good average shape.
b) Now why would they all be cubical?
d) Sounds plausible, but no one mentions this.
e) We can’t even prove there is a Planet X based on the most obvious
perturbations it should cause.

Redaction: Jeffery, 2001 jan 01

027 qmult 00200 1 1 1 easy memory: Jupiter’s order number and mass
123. In our solar system, Jupiter is:
   a) the most massive planet and the fifth planet from the Sun.
   b) the most massive planet and the sixth planet from the Sun.
   c) the second most massive planet and the fourth planet from the Sun.
   d) the fifth most massive planet and the third planet from the Sun.
   e) a large asteroid that crosses both the orbits of Mars and Earth. It represents a
perennial hazard to all life on Earth.

SUGGESTED ANSWER: (a)

Wrong answers:
   d) This is Earth.

Redaction: Jeffery, 2001 jan 01

027 qmult 00400 2 4 3 moderate deducto-memory: Jupiter composition
124. 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 (NH₃). There may be methane on Jupiter
too.
   b) No.
   d) Hydrogen more than helium.
   e) Same as (a)

Redaction: Jeffery, 2001 jan 01
027 qmult 00600 1 4 1 easy deducto-memory: Jupiter’s Great Red Spot
125. Jupiter’s Great Red Spot is:
   a) a long-lasting storm.
   b) a remnant of the impacts of the cometary fragments of comet Shoemaker-Levy 9.
   c) a red iceberg floating on molecular hydrogen gas.
   d) a storm that has existed only a few years and will likely dissipate in another ten years or so.
   e) actually on Saturn.

SUGGESTED ANSWER: (a)

Wrong answers:
   e) As Lurch would say: “Aaaarrh.”

Redaction: Jeffery, 2001jan01

027 qmult 00900 2 4 4 moderate deducto-memory: Jupiter’s radiation
126. 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 01000 3 1 3 tough memory: Jupiter’s magnetic field
127. Jupiter probably has a strong magnetic field because of the dynamo effect. Why should Jupiter have a strong dynamo effect? It rotates ________ and probably has a deep convective layer of _________.

a) rapidly; hydrogen ice  b) rapidly; liquid molecular hydrogen  c) rapidly; liquid metallic hydrogen  d) slowly; helium oxide  e) rapidly; helium oxide

SUGGESTED ANSWER: (c) One has to remember that there are both liquid molecular and liquid metallic hydrogen layers and the metallic hydrogen is the conductor needed for the dynamo effect.

Wrong answers:
   e) Helium is a noble gas and doesn’t easily form compounds. In fact I’ve never heard of helium compound. Some noble gases can be combined in compounds though: xenon and kryton, I believe.

Redaction: Jeffery, 2001 Jan 01

128. 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, 2001 Jan 01

129. Why has Io perhaps been especially heavily impacted for a solar system body? Why is Io relatively uncratered by impacts compared to most solar system moons?

a) It has perhaps been especially heavily impacted because of its GREAT VOLCANIC ACTIVITY. The closeness to Jupiter explains the lack of cratering.
   b) It has perhaps been especially heavily impacted because JUPITER’S STRONG GRAVITATIONAL FIELD attracts impactors. Io’s LIQUID SURFACE cannot, of course, be cratered.
c) It has perhaps been especially heavily impacted because JUPITER’S STRONG GRAVITATIONAL FIELD attracts impactors. Io’s ICE SURFACE cannot, of course, be cratered.

d) It has perhaps been especially heavily impacted because JUPITER’S FAST ROTATION RATE attracts impactors. Io’s SNOW SURFACE cannot, of course, be cratered.

e) It has perhaps been especially heavily impacted because JUPITER’S STRONG GRAVITATIONAL FIELD attracts impactors. Io’s GREAT VOLCANIC ACTIVITY constantly renews its surface and relatively quickly eliminates any traces of impacts.

SUGGESTED ANSWER: (e) I think Jupiter’s gravity probably attracts impactor especially. But I’m not sure that this leads to especially heavy impact rates on Io. I should find out some day. It seems reasonable though. See Se-507 for Io’s lack of impact craters.

Wrong answers:
b) Io doesn’t have a liquid surface.

Redaction: Jeffery, 2001 jan01

027 qmult 01700 2 4 2 moderate deducto-memory: Io’s geology driver 130. The cause of Io’s great geological activity is:

a) Jupiter’s tidal force. Because of its CIRCULAR ORBIT, the tidal force continually flexes Io’s interior leading to internal heating. The heat causes volcanism.

b) Jupiter’s tidal force. Because of its ECCENTRIC ORBIT, the tidal force continually flexes Io’s interior leading to internal heating. The heat causes volcanism.

c) the great flux of impactors attracted by Jupiter. The impactors plunge deeply into Io and cause INTENSE SHOCK FORCES that cause heat. The heat causes volcanism.

d) the great flux of impactors attracted by Jupiter. The impactors plunge deeply into Io and release RADIOACTIVE MATERIAL. The radioactive material decays and so generates heat. The heat causes volcanism.

e) LEFTOVER INTERNAL HEAT from the time of formation. The heat causes volcanism.

SUGGESTED ANSWER: (b) By now tidal heating has probably been drilled into the brains of those who come to class.

Wrong answers:
e) Not tiny little Io.

Redaction: Jeffery, 2001 jan01

028 qmult 04000 2 4 2 moderate deducto-memory: Saturn’s ring material 131. 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) **HELUM 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) **HELUM 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, 2001 jan 01

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032 qmult 00100 1 4 3 easy deducto-memory: meteor/oid/rite

132. Let’s get the terminology straight once and for all.

a) **meteors** travel in space, **meteoroids** shoot in the sky, and **meteorites** hit the Earth.

b) **meteoroids** travel in space, **meteorites** shoot in the sky, and **meteors** hit the Earth.

c) **meteoroids** travel in space, **meteors** shoot in the sky, and **meteorites** hit the Earth.

d) **meteorology** travels in space, **meteorlights** shoot in the sky, and **meteorealis** hits the Earth.

e) **meteorology** travels in space, **meteorlights** shoot in the sky, and **Montreal** hits the Earth.

**SUGGESTED ANSWER:** (c) General knowledge and elimination help.

**Wrong answers:**

e) Required Canadian content.

**Redaction:** Jeffery, 2001 jan 01

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032 qmult 00400 1 4 5 easy deducto-memory: largest asteroid Ceres II

133. The largest asteroid (i.e., minor planet confined within about the orbit of Jupiter) is:
a) Pluto. b) Pittsburgh. c) 1997 XF11 which will impact the Earth (near Pittsburgh) in 2028. d) Phobos. e) Ceres.

**SUGGESTED ANSWER:** (e)

**Wrong answers:**

a) Pluto’s a planet, cowboy. At least by IAU definition.

b) There may be a Pittsburgh asteroid: there is a Chicago asteroid. But it’s not the right answer if it were such.

c) The students (in 1999) should have heard of Brian Marsden’s famous announcement of a remote possibility of 1997 XF11 hitting the Earth, which became an effectively zero possibility the next day. And 1997 XF11 was only kilometerish. And if the haven’t, they should still be able to guess that we aren’t going to be hit from our lack of running in circles and screaming and shouting.

d) A Martian moon.

**Redaction:** Jeffery, 2001Jan01

032 qmult 00600 1 4 3 moderate deducto-memory: asteroid origin

134. Asteroids (i.e., minor planets confined within about the orbit of Jupiter) are probably mainly:

a) icy planetesimals left over from the formation of the solar system.

b) fragmented or unfragmented icy planetesimals or protoplanets left over from the formation of the solar system.

c) fragmented or unfragmented rocky planetesimals or protoplanets left over from the formation of the solar system.

d) star-like objects beyond the orbit of Pluto.

e) star-like objects closer to the Sun than the orbit of Mars.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**

e) As Lurch would say: “Aaaarh.”

**Redaction:** Jeffery, 2001Jan01

032 qmult 00700 1 4 1 moderate deducto-memory: Asteroid Belt location

135. The Asteroid Belt is located:

a) between the orbits of Mars and Jupiter. b) between the orbits of Mercury and Venus. c) beyond the orbit of Pluto. d) inside the Sun. e) between the Sun and the orbit of Vulcan.

**SUGGESTED ANSWER:** (a)

**Wrong answers:**

b) Nah.

c) That’s the Kuiper Belt.

d) Vaya.
e) There is no Vulcan other than on *Star Trek*.

**Redaction:** Jeffery, 2001 Jan 01

032 qmult 00710 1 4 2 easy deducto-memory: asteroid asymmetry

136. An asteroid less than 300 km in size scale:

   a) must be spherical.  
   b) can be asymmetric.  
   c) must be cubical.
   d) must be green.  
   e) must tetrahedral.

**SUGGESTED ANSWER:** (b)

**Wrong answers:**

   e) A four-sided figure with each side being triangular. It’s a traingular pyramid.

**Redaction:** Jeffery, 2001 Jan 01

032 qmult 00800 3 3 4 tough math: meteoroid kinetic energy

137. The kinetic energy of a body of speed \( v \) and mass \( m \) is given by the formula

\[
E_{\text{Kin}} = \frac{1}{2}mv^2.
\]

A typical meteoroid (a small body in space: it becomes a meteor in precise speech only when it penetrates the Earth’s atmosphere) has a speed of order 30 km/s = 30,000 m/s relative to the Earth. Given that it has a mass of 1g (note: 1 gram), what is the kinetic energy of this typical meteoroid? (Note that a 1 kg mass falling 1 m under the force of gravity near the Earth’s surface acquires about 10 J of kinetic energy.)

   a) 10 J.  
   b) \( 4.5 \times 10^8 \) J.  
   c) \( 9 \times 10^8 \) J.  
   d) \( 4.5 \times 10^5 \) J.  
   e) \( 9 \times 10^5 \) J.

**SUGGESTED ANSWER:** (d) The trick is too get the units right. They have to know that grams must be converted to kilograms.

**Wrong answers:**

   e) You forgot the 1/2.

**Redaction:** Jeffery, 2001 Jan 01

032 qmult 00900 2 5 2 moderate thinking: asteroid discovery

138. The asteroids (i.e., minor planets confined within about the orbit of Jupiter) which were discovered early on are much larger than typical asteroids we discover today. Why?

   a) The biggest asteroids are more easily resolved. Thus they were found first.
   b) The biggest asteroids tend to reflect the most sunlight, and thus they are brighter and more obvious. Therefore they were found first.
   c) The biggest asteroids are simply much more numerous. Thus, the odds are that the biggest asteroids would be discovered first.
   d) The biggest asteroids were found first just by accident.
   e) The biggest asteroids cause huge gravitational perturbations of Jupiter’s orbit. Early 17th century mathematical astronomers were able to deduce the
approximate positions of the biggest asteroids. Subsequent searches quickly found these bodies.

**SUGGESTED ANSWER:** (b)

**Wrong answers:**

a) Even the biggest asteroids aren’t usually resolved. Ceres at opposition is only 0.732 arcseconds. And even if they are resolved, there disks hardly an eye-catcher.

c) No the biggest asteroids are least numerous.

d) No, the biggest ones were easy to find because of (b)

e) Can the minute asteroids that altogether total about 0.0003 Earth masses (Cox-293) perturb massive Jupiter significantly enough for anyone to calculate their positions? Well I don’t know, but I doubt it. Anyway early Seventeenth century astronomers didn’t have the Newton’s laws of motion and gravity and couldn’t have done the job.

**Redaction:** Jeffery, 2001 jan01

032 qmult 01000 2 4 2 moderate deducto-memory: asteroid radioactive

139. Why couldn’t radioactive potassium ($^{40}$K; half-life 1.30 billion years), thorium ($^{232}$Th; half-life 14.1 billion years), or uranium ($^{238}$U; half-life 4.50 billion years) have melted the rocky planetesimals (which were the parent bodies for the asteroids) and caused them to chemically differentiate?

a) Because of their small size, the planetesimals will lose heat **SLOWLY** through their surface to space. Thus the heat from radioactive species with long half-lives cannot accumulate sufficiently to melt the planetesimals. It has been hypothesized that radioactive aluminum ($^{26}$Al; half-life 0.742 million years), which releases heat relatively quickly, accounts for heat accumulation sufficiently rapid to cause planetesimal melting.

b) Because of their small size, the planetesimals will lose heat **RAPIDLY** through their surface to space. Thus the heat from radioactive species with long half-lives cannot accumulate sufficiently to melt the planetesimals. It has been hypothesized that radioactive aluminum ($^{26}$Al; half-life 0.742 million years), which releases heat relatively quickly, accounts for heat accumulation sufficiently rapid to cause planetesimal melting.

c) None of these radioactive nuclear species (i.e., radioactive nuclides) were contained in the material that formed the planetesimals in the Asteroid Belt area of the solar system. The radioactive nuclides are all highly **NON-VOLATILE**, and so **ONLY** condensed in the **INNER REGION** of the solar system where almost all the material got incorporated into rocky planets. The radioactive nuclides in the rocky planets, of course, help to melt and elementally differentiate them.

d) None of these radioactive nuclear species (i.e., radioactive nuclides) were contained in the material that formed the planetesimals in the Asteroid Belt area of the solar system. The radioactive nuclides are all highly **VOLATILE**, and so **ONLY** condensed in the **FAR OUTER REGION** of the solar system where almost all the material got incorporated into Uranus, Neptune, and icy
planetesimals (Pluto being considered the largest of these). The radioactive nuclides in these gas giant planets and icy planetesimals, of course, help to melt and elementally differentiate them.

e) There is no known reason why they couldn't have. That they didn't is a mystery.

**SUGGESTED ANSWER:** (b) See Se-557. I'm guessing about the isotope of Th by the way: it's the only sufficiently long-lived thorium isotope, but maybe another Th isotope has a long-lived radioactive daughter: I doubt this though. The key point is that small bodies lose heat quickly.

**Wrong answers:**

a) rapidly not slowly.

c) Non-volatile elements condense out everywhere and these radioactive elements are non-volatile although potassium is chemically highly reactive which I guess means it's usually chemically bound to something else.

d) These elements are not volatiles and students should recall that they are thought to help melt the inner planets.

e) It's not a mystery. See the correct answer (b).

**Redaction:** Jeffery, 2001jan01

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140. In 1908, an impactor (perhaps a small asteroid of order 30 m in scale) hit the Earth in:


**SUGGESTED ANSWER:** (b)

**Wrong answers:**

e) This happened 65 Myr ago and was probably dinosaursical.

**Redaction:** Jeffery, 2001jan01

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141. The supposed dinosaursical impactor hit near:


**SUGGESTED ANSWER:** (e)

**Wrong answers:**

a) That was in 1908.

**Redaction:** Jeffery, 2001jan01

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143. After the impact, the atmosphere of the Earth changed. It also experienced:

a) Air pollution.  b) An increase in global temperature.  c) Sudden drop in global temperature.  d) Hard rain.  e) All of the above.

**SUGGESTED ANSWER:** (e)

**Wrong answers:**

a) Only if the right mix of dust, moisture and chemicals are available.

c) No. The tropics can't be cold.

d) No. The tropics can't have hard rain.

e) Only if the right mix of dust, moisture and chemicals are available.

**Redaction:** Jeffery, 2001jan01
142. “Let’s play Jeopardy! For $100, the answer is: This fragmented comet impacted on Jupiter in 1994.”

What is Comet ___________, Alex?

a) Tunguska  
b) Halley  
c) Shoemaker-Levy 9  
d) Cobbler-Dam IX  
e) Hale-Bopp?

**SUGGESTED ANSWER:** (c)

**Wrong answers:**
d) Sort of a synonym for the right answer.

**Redaction:** Jeffery, 2001jan01

032 qmult 01600 2 4 3 easy deducto-memory: impactor cube-law

143. Why is a 100-meter diameter Earth-bound impactor much more worrisome than a 10-meter diameter one?

a) Mass and kinetic energy tend to be proportional to **DIAMETER**. The 100-meter impactor will thus tend to be ten times more devastating than the 10-meter one.
b) Mass and kinetic energy tend to be proportional to the **SQUARE OF DIAMETER**. The 100-meter impactor will thus tend to be a hundred times more devastating than the 10-meter one.
c) Mass and kinetic energy tend to be proportional to the **CUBE OF DIAMETER**. The 100-meter impactor will thus tend to be a thousand times more devastating than the 10-meter one.
d) It is not more worrisome. The bigger the impactor, the less effect on the target.
e) The smaller impactors always land in the oceans.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**
a) Mass and kinetic energy tend to go like the cube.
b) Mass and kinetic energy tend to go like the cube.
d) Not likely.
e) No they don’t.

**Redaction:** Jeffery, 2001jan01

032 qmult 03000 1 5 2 easy thinking: why support Spacewatch

144. Why might a person support the search by Spacewatch (or whoever) for solar system bodies that could impact the Earth?

a) Never in human history has there been significant harm from an impact event. Annie Hodges of Sylacauga, Alabama in 1954 November was awoke from a nap by a meteorite coming through her roof and bouncing off her radio set and then her arm and leg. Probably it left nasty bruises. Wanda and Robert Donahue of Wethersfield, Connecticut in 1982 November (November is the cruelest month) were disturbed (while watching M*A*S*H) when a 3 kg meteorite came through their roof, bounced up into the attic, and came to rest under the dining room
table. Michelle Knapp of Peekskill, New York in 1992 October woke up to find her 1980 Chevy Malibu (just bought from her grandmother) had its rear end smashed by a 1.5 kg meteorite that cratered the driveway. These and other impact events on the human condition, totaling 61 recorded incidents in the period ~ 1790–1990, haven’t amounted to much compared to other tribulations.

b) Although that the risk of significant harm is small, it is real. Tunguska-like events probably happen once a century or so (or maybe every two thousand years or so), but usually in oceans or relatively uninhabited and out-of-world locations. With the world more populated today and more connected, a Tunguska-like event with heard-of tragic consequences could happen any century. Widespread or global devastation events (as the Chicxulub event was supposed to have been) are extremely rare, but they can happen too. So it is probably worthwhile to support a modest public program to discover dangerous solar system bodies especially as some of the searchers (space guards?) are unpaid volunteer enthusiasts. Maybe we could do something—duck for instance. Still we’ll probably never be able to protect our cars from Peekskill-like events.

c) To prevent ozone loss.
d) To prevent coffee stains.
e) For peace on Earth, goodwill toward humankind.

SUGGESTED ANSWER: (b)

Wrong answers:
a) This isn’t an answer to the question, no matter how reasonable it sounds. See FMW-275.

c) No one could possibly think ozone loss was caused by impacts. Well a big enough impact probably would effect the ozone layer, but we’d have other things to worry about.

d) No one could possibly think coffee stains were caused by impacts.

e) Given the context of the question, this isn’t the best answer. It is the Christmas answer.

Redaction: Jeffery, 2001 jan01