Introductory Astronomy

Homework 8: The Sun Not to be handed in. Homework solutions are posted already.

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008 qmult 00200 1 4 3 easy deducto-memory: Sun diameter

1. The diameter of the Sun is about:

   a) 1 Earth diameter, b) 30 Earth diameters , c) 109 Earth diameters, d) 1 astronomical unit, e) 1 light-year.

   SUGGESTED ANSWER: (c) Ni-117 gives 109 Earth diameters and that sounds about right.

   Wrong answers:
   a) This would make the Sun the same size as the Earth.
   d) This would make the Sun's surface extend right to Earth's orbit.

   Redaction: Jeffery, 2001jan01

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008 qmult 00220 1 4 3 easy deducto-memory: solar luminosity

Extra keywords: CK-262,266

2. The solar luminosity is $L_\odot =$:

   a) 100 W. b) 3.86×10^{-26} W. c) 3.86×10^{26} W. d) 1.496×10^{11} m. e) 6.9599×10^{8} m.

   SUGGESTED ANSWER: (c)

   Wrong answers:
   a) An incandescent light in your room has the same luminosity as the Sun.
   d) This is the astronomical unit. The meter unit should be a clear giveaway.
   e) This is the solar radius to the photosphere. The meter unit should be a clear giveaway.

   Redaction: Jeffery, 2001jan01

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008 qmult 00230 1 1 5 easy memory: Sun photosphere temperature

3. 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, 2001jan01

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008 qmult 00240 2 4 1 moderate deducto-memory: Sun central temperature

4. The temperature at the center of the Sun is about:

   a) 16×10^6 K as known from modeling. b) 16×10^6 K as known from direct measurement. c) 273 K. d) 6000 K as known from modeling. e) 6000 K as known from direct measurement.

   SUGGESTED ANSWER: (a)

   Wrong answers:

e) This is about the photospheric temperature which is known from the near blackbody emission of the Sun.

Redaction: Jeffery, 2001jan01

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008 qmult 00252 1 1 1 easy memory: solar constant value

5. 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) $1367\,\mathrm{W/m^2}$. b) $1000.00\,\mathrm{W/m^2}$. c) 0. d) $-1367\,\mathrm{W/m^2}$. 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, 2001jan01

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008 qmult 00256 2 5 5 moderate thinking: solar constant and light bulbs

6. 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 about 1367 watts per square meter. If one had a square kilometer of solar panels (of 100 % efficiency), how many 100 watt light bulbs could you run on solar power assuming no loss due to atmospheric absorption or reflection?

a) 100 watts. b) 1000. c) 1367. d) 1.37×10^{11}. e) 1.37×10^{7}.

SUGGESTED ANSWER: (e) Well

$$1367\,\mathrm{W/m^2} \times \left(\frac{10^3\,\mathrm{m}}{1\,\mathrm{km}}\right)^2 \left(\frac{1\,\text{light bulb}}{100\,\mathrm{W}}\right) = 1.367 \times 10^7\,\text{light bulbs/km}\ .$$

Wrong answers:

a) Wrong number, wrong units.

d) This is obtained by multiplying by 100, not dividing by 100.

Redaction: Jeffery, 2001jan01

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008 qmult 00300 1 4 5 easy deducto-memory: interior of Sun specified

Extra keywords: CK-263,267-4

7. "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, 2001jan01

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008 qmult 00310 1 4 3 easy deducto-memory: radiative transfer in Sun

8. Out to about 71 % of the Sun's radius, the dominant energy transfer mechanism is:

a) electron conduction. b) neutrino transfer. c) radiative transfer (i.e., transfer by electromagnetic radiation). d) convection. e) an explosive shock wave.

SUGGESTED ANSWER: (c) This is energy transfer by EMR. Cox-342 and CM-243 say 71 % which agrees with older references.

Wrong answers:

a) This is important in metals.
b) This is important during the core collapse phase of supernovae
e) This is important during the explosion phase of supernovae.

Redaction: Jeffery, 2001jan01

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008 qmult 00450 2 1 3 moderate memory: solar granule

9. 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, 2001jan01

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

10. 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, 2001jan01

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008 qmult 00514 1 4 1 easy deducto-memory: two of five Sun outer layers III

11. Two of the five outermost layers of the Sun (defining layers of the Sun generously) are:

a) photosphere and chromosphere. b) carnation and corona. c) corona and paloma. d) rio and sands. e) chromosphere and Asteroid Belt.

SUGGESTED ANSWER: (a)

Wrong answers:
d) Rio and sands? This is the Las Vegas answer.

Redaction: Jeffery, 2001jan01

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008 qmult 00710 1 1 4 easy memory: corona visible to unaided eye

12. The corona of the Sun is only visible to the unaided eye:

a) at sunset. b) when the Moon is a crescent in the western sky. c) during partial solar eclipses. d) during total solar eclipses. e) when the Sun is below the horizon.

SUGGESTED ANSWER: (d)

Wrong answers:
c) Well no.

Redaction: Jeffery, 2001jan01

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008 qmult 00800 1 4 4 easy deducto-memory: solar wind defined

13. The solar wind is:

a) the air that blows off the northern hemisphere oceans during geomagnetic storms.
b) the plasma gas that cools the Sun's photosphere.
c) an optical illusion in the corona that causes the corona to look like fluffy orange clouds.
d) the plasma gas that streams from the Sun out into **INTERSTELLAR SPACE**.
e) the plasma gas that streams from the Sun out into **INTERGALACTIC SPACE**.

SUGGESTED ANSWER: (d)

Wrong answers:
e) The solar wind doesn't make it to intergalactic space.

Redaction: Jeffery, 2001jan01

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008 qmult 00810 1 4 4 easy deducto-memory: solar wind speed

14. The solar wind is a stream of particles that moves approximately along radial paths outward from the Sun: inward is the negative direction and positive is the outward direction. The solar wind near the Earth is typically moving at a radial velocity of about:

a) $-200\,\mathrm{km/s}$. b) $-200\,\mathrm{m/s}$. c) $-200\,\mathrm{cm/s}$. d) 400 to $500\,\mathrm{km/s}$ e) 400 to $500\,\mathrm{km}$.

SUGGESTED ANSWER: (d)

Wrong answers:
e) Wrong units.

Redaction: Jeffery, 2001jan01

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008 qmult 00820 2 3 5 moderate math: solar wind mass loss I

15. The Sun loses mass at a rate of about 2×10^9 kg/s. Convert this rate into solar masses per year to the same accuracy as given. **NOTE:** The mass of the Sun is $M_\odot = 1.9891 \times 10^{30}$ kg and the length of a year in seconds to 0.5 % accuracy is $\pi \times 10^7$ s.

    a) 2×10^{30} kg/yr. b) $2 \times 10^{-30}\, M_\odot$/yr. c) $2 \times 10^9\, M_\odot$/yr. d) $3 \times 10^{14}\, M_\odot$/yr. e) $3 \times 10^{-14}\, M_\odot$/yr.

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

    Wrong answers:
    d) The Sun would be gone in a flash at this rate.

    Redaction: Jeffery, 2001jan01

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

16. The Sun loses mass at a rate of $\sim 2 \times 10^9\,\mathrm{kg\,s^{-1}} \sim 3 \times 10^{-14}\, M_\odot$/yr. (Note that $M_\odot$ 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) $\sim 10^{10}$ yr = 10 Gyr. b) $\sim 10^9$ s. c) $\sim 3 \times 10^{13}$ yr = 3×10^4 Gyr. d) $\sim 5 \times 10^9$ yr = 5 Gyr. e) $\sim 3 \times 10^{13}$ s.

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

    Wrong answers:
    e) Wrong units.

    Redaction: Jeffery, 2001jan01

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008 qmult 00900 2 4 4 moderate deducto-memory: charge in magnetic fields

17. Magnetic fields:

    a) are caused by **ELECTRIC CURRENTS** (and time varying electric fields) and tend to cause charged particles to **PERAMBULATE**.
    b) are caused by **ELECTRIC CURRENTS** (and time varying electric fields) and tend to cause charged particles to **ACCELERATE** to the speed of light.
    c) are caused by **HEAT** and tend to cause charged particles to **ACCELERATE** to the speed of light.
    d) are caused by **ELECTRIC CURRENTS** (and time varying electric fields) and tend to cause charged particles to move in **SPIRALS**.
    e) are caused by **HEAT** and tend to cause charged particles to move in **SPIRALS**.

    SUGGESTED ANSWER: (d) An easy memory question for those who attend or read the web lectures.

    Wrong answers:
    a) Perambulate usually means walking and in any case is rather nonsensical in this contex.t

Redaction: Jeffery, 2001jan01

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008 qmult 00920 1 4 1 easy deducto-memory: solar wind and Earth

18. The Earth's magnetic field:

a) gives **CONSIDERABLE** protection from the high-energy charged particles in the solar wind.
b) gives **NO** protection from the high-energy charged particles in the solar wind.
c) gives **CONSIDERABLE** protection from the high-energy charged particles in the solar wind. It also **STOPS** all high-energy electromagnetic radiation from reaching the Earth's surface.
d) gives **NO** protection from the high-energy charged particles in the solar wind. But it does **STOP** all high-energy electromagnetic radiation from reaching the Earth's surface.
e) is in the green band of the electromagnetic spectrum.

SUGGESTED ANSWER: (a)

Wrong answers:
d) No and no.
e) A nonsense answer.

Redaction: Jeffery, 2001jan01

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008 qmult 01000 2 4 1 moderate deducto-memory: solar magnetic field

19. The magnetic field of the Sun is caused by

a) electrical currents inside the Sun. b) blackbody radiation. c) the Doppler effect. d) charged particles undergoing a Doppler shift. e) the aurora.

SUGGESTED ANSWER: (a)

Wrong answers:
b) As Lurch would say: "Aaaah."

Redaction: Jeffery, 2001jan01

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008 qmult 01100 1 1 1 easy memory: sunspots defined

20. 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, 2001jan01

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008 qmult 01110 2 1 1 moderate memory: sunspot cycle

21. The mean length of the full sunspot cycle is:

a) 22 years. b) 220 years. c) 24 hours. d) 2000 years. e) 8 minutes.

SUGGESTED ANSWER: (a) The sunspot cycle is broken into two subcycles of 11 years each. Sometimes one refers to the 11 year sunspot cycle. This is an ambiguity that just has to be dealt with.

Wrong answers:
c) This is the length of the standard day.

Redaction: Jeffery, 2001jan01

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008 qmult 01130 2 4 5 moderate deducto-memory: sunspot cause mag-fields

22. Why do solar astrophysicists think the sunspots are caused magnetic field effects?

a) Because one of the pair of sunspots has a strong magnetic field. The other doesn't, but that **MAY NOT** be a problem with the theory.
b) Because one of the pair of sunspots has a strong magnetic field. The other doesn't and that **IS** a problem with the theory.
c) Because sunspots emit **BLACKBODY RADIATION** which is caused by magnetic fields. Moreover, all sunspots have **RELATIVELY STRONG MAGNETIC FIELDS**. The fact that sunspots come in pairs strongly suggests that magnetic field lines emerge from one member of a pair and enter the other member.
d) Because sunspots emit a **LINE SPECTRUM** which is caused by magnetic fields. Moreover, all sunspots have **RELATIVELY STRONG MAGNETIC FIELDS**. The fact that sunspots come in pairs strongly suggests that magnetic field lines emerge from one member of a pair and enter the other member.
e) All sunspots have **RELATIVELY STRONG MAGNETIC FIELDS**. The fact that sunspots come in pairs strongly suggests that magnetic field lines emerge from one member of a pair and enter the other member.

SUGGESTED ANSWER: (e)

Wrong answers:
a) Both sunspots have strong magnetic fields.
b) Both sunspots have strong magnetic fields.
c) Blackbody radiation is caused by finite temperature dense materials. The rest of the answer is correct.
d) Blackbody radiation is caused by finite temperature rarefied gases. The rest of the answer is correct.

Redaction: Jeffery, 2001jan01

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008 qmult 01200 1 4 4 easy deducto-memory: solar prominences defined

23. "Let's play *Jeopardy*! For $100, the answer is: These solar activities are arcs of hot gas with temperatures of order 10000 K that rise from the Sun. They can rise in hours and last weeks or months in which case they are quiescent. Or they can arise eruptively in a few hours and eject matter into space in which case they are eruptive."

What are _____, Alex.

a) sunspots b) coronas c) granules d) prominences e) salients

SUGGESTED ANSWER: (d)

Wrong answers:
e) Salient can mean prominent, but a salient is not a prominence.

Redaction: Jeffery, 2001jan01

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008 qmult 02000 1 4 1 easy deducto-memory: solar flares defined

24. "Let's play *Jeopardy*! For $100, the answer is: These solar activities are giant explosions from the Sun with energies up to of order 10^{25} J (i.e., 2.5×10^9 megatons of TNT) with temperatures up to 5×10^6 K. They are believed to be caused by magnetic reconnection in which magnetic field energy is rapidly converted to thermal, electromagnetic radiation, and kinetic energy."

What are _____, Alex.

a) solar flares b) granules c) granolas d) grains e) gravitons

SUGGESTED ANSWER: (a)

Wrong answers:
c) Granola is a form of breakfast.
e) A graviton is the quantum particle of the gravity field. So far they are purely theoretical entities: we've never detected them even indirectly.

Redaction: Jeffery, 2001jan01

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008 qmult 02100 1 4 5 easy deducto-mem.: solar coronal mass ejections defined

25. "Let's play *Jeopardy*! For $100, the answer is: They are giant bubbles of hot gas ejected from the Sun within the time span of a few hours. If they impact the Earth's magnetosphere, they can cause magnetic storms and strong auroras."

What are _____, Alex?

a) helium atoms b) hydrogen atoms c) granules d) sunspots e) coronal mass ejections

SUGGESTED ANSWER: (e)

Wrong answers:
a) Helium atoms may form a giant bubble of hot gas, but they are not a giant bubble of hot gas.

Redaction: Jeffery, 2001jan01

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008 qmult 02110 1 5 5 easy thinking: killer coronal mass ejections

26. In a best-selling novel of a few years ago (unless my source is just making this up), astronauts on the Moon were killed by high-energy protons from a coronal mass ejection (CME) that reached the Moon 8 minutes after the CME was ejected. What was wrong with this plot device?

a) High-energy protons never hurt anyone.
b) CMEs always happen near the solar poles and all the particles they eject get directed off in the solar polar direction: they never head toward Earth (or the Moon).
c) If one divides 8 minutes by the speed of light, one gets 36 hours. Clearly the astronauts could not have been affected until 36 hours after the CME.
d) If one divides 1 astronomical unit by the the speed of light, one gets 36 hours. Clearly the astronauts could not have been affected until 36 hours after the CME.
e) Particles with finite mass cannot move at the speed of light. 8 minutes is roughly the travel time for light from the Sun. (If you don't believe me, divide 1.496×10^{13} cm by 3.00×10^{10} cm/s and see what you get.) The protons couldn't have gotten to the Moon in 8 minutes or at least not in the exact light travel time. They could do it in a time very close to the exact light travel time if they were super-energetic: such super-energetic solar protons have not been observed. I don't think the author could have been Larry Niven.

SUGGESTED ANSWER: (e) Basically an easy thinking question, but I've thrown in some

thought provoking (I hope) red herrings that could stimulate some thought on the part of the students. Still the longest-answer-is-the-right-answer rule works for this question. From what Se-160 says it seem that solar protons at most reach about 1/3 of the speed of light.

The reference for the bestseller is Se-165.

Se-160 doesn't refer to CMEs just flares. But it is clear that from other sources, that CME is really the event that gives the large gust. CMEs probably often arise from flares.

Wrong answers:

a) Any ionizing radiation can hurt you I'd guess.

Redaction: Jeffery, 2001jan01

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038 qmult 00200 1 4 5 easy deducto-memory: solar composition

Extra keywords: Sun-question

27. The Sun's surface composition by mass (which approximates the average cosmic composition and is typical of non-ancient stars) is about:

a) 100 % helium.
b) 71 % hydrogen, 27 % nitrogen, and 20 % everything else.
c) 71 % carbon, 27 % nitrogen, and 2 % everything else.
d) 71 % hydrogen, 27 % nitrogen, and 2 % everything else.
e) 71 % hydrogen, 27 % helium, and 2 % everything else.

SUGGESTED ANSWER: (e) The solar composition is pretty close to the average cosmic composition. The values come from Cox-28, but are rounded-off to whole numbers.

Wrong answers:

a) Well word helium is derived from the Greek word for the Sun and the Sun god: Helios
b) This composition doesn't add up to 100 %.

Redaction: Jeffery, 2001jan01

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038 qmult 00600 1 1 4 easy memory: luminosity defined I

Extra keywords: CK-276,277, Sun-question

28. The total power of a star (i.e., energy output per unit time) is called:

a) brightness. b) rightness. c) lightness. d) luminosity. e) incandescence.

SUGGESTED ANSWER: (d)

Wrong answers:

e) This is usually the state of being white hot.

Redaction: Jeffery, 2001jan01

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038 qmult 00700 1 4 5 easy deducto-memory: flux defined

Extra keywords: Sun-question

29. "Let's play *Jeopardy*! For $100, the answer is: This is the energy per unit area per unit time **OR** the energy per unit area in some wavelength band **OR** the energy per unit area per unit time per unit wavelength (or frequency) from some light source (e.g., a star or the Sun)."

What is _____, Alex?

a) fugue b) flow c) luminosity d) light e) flux

SUGGESTED ANSWER: (e)

Wrong answers:
a) Strictly for classical music aficionados.

Redaction: Jeffery, 2001jan01

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041 qmult 00110 1 4 5 easy deducto-memory: main sequence star physically
Extra keywords: CK-310 Sun-question

30. "Let's play *Jeopardy*! For $100, the answer is: It is a star that as observed over relatively short times scales (e.g., all of human history) is burning hydrogen to helium in its core at a constant rate and is in hydrostatic equilibrium."

What is a/an _____, Alex?

a) dense core b) protostar c) pre-main-sequence star d) H II region e) main sequence star

SUGGESTED ANSWER: (e)

Wrong answers:
d) Oh, c'mon.

Redaction: Jeffery, 2001jan01

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041 qmult 00120 1 4 4 easy-deducto memory: MS energy balance
Extra keywords: Sun-question

31. For a main sequence star, the energy radiated away as electromagnetic radiation is almost exactly compensated by:

a) gravitational energy converted to heat energy during rapid collapse. b) neutrinos from space being absorbed by the star. c) energy produced by nuclear burning on the surface. d) energy produced by nuclear burning in the deep interior. e) nothing at all.

SUGGESTED ANSWER: (d)

Wrong answers:
a) Energy from collapse is important during star formation and post-main sequence evolution, but it is not so important on the main sequence itself.
e) As Lurch would say: "Aaaarh."

Redaction: Jeffery, 2001jan01

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041 qmult 00200 1 1 1 easy memory: nuclei made of protons, neutrons
Extra keywords: Sun-question

32. Atomic nuclei are made up of:

a) protons and neutrons. b) protons and electrons. c) positrons and electrons. d) positrons and neutrals. e) ponytrons and nuggets.

SUGGESTED ANSWER: (a)

Wrong answers:
c) A positron is the antiparticle of an electron: i.e., its the antielectron.
e) As Lurch would say: "Aaaarh."

Redaction: Jeffery, 2001jan01

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041 qmult 00220 1 1 3 easy memory: isotopes defined
Extra keywords: Sun-question

33. Nuclei with the same number of protons, but different number of neutrons are _____ of each other.

a) isochrones b) isobars c) isotopes d) isodopes e) Isoldes

SUGGESTED ANSWER: (c)

Wrong answers:
a) Contours of the same time.
b) Contours of the same pressure.
d) Contours of the same stupidity.
e) Isolde or Iseult is the heroine (heroin?) of the Arthurian romance of Tristan and Isolde:

Nay, order him!
Pray understand it!
I command it.
I Isolde.

Redaction: Jeffery, 2001jan01

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041 qmult 00230 1 4 4 easy deducto-memory: deuteron and triton
Extra keywords: Sun-question

34. "Let's play *Jeopardy*! For $100, the answer is: These isotopes of hydrogen have 1 and 2 neutrons, respectively."

What are _____, Alex?

a) uranium-235 (^{235}U) and uranium-238 (^{238}U) b) helium-3 (^{3}He) and helium-4 (^{4}He) c) the deuteronomy (D or ^{2}H) and trident (T or ^{3}H) d) the deuteron (D or ^{2}H) and triton (T or ^{3}H) e) carbon (C) and oxygen (O)

SUGGESTED ANSWER: (e)

Wrong answers:
b) Helium-3 to helium-4 ratio is about $1/10^6$ by number??? (En-528).
c) Deuteronomy is the 5th book of the Pentateuch and is a second statement of the Mosaic law. It's about where most would-be-whole Bible readers languish.

Redaction: Jeffery, 2001jan01

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041 qmult 00240 1 1 5 easy memory: strong nuclear force binds nuclei
Extra keywords: Sun-question

35. Nuclei are bound together by:

a) gravity. b) the electromagnetic force. c) the centrifugal force. d) the weak nuclear force. e) the strong nuclear force.

SUGGESTED ANSWER: (c)

Wrong answers:
c) 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, 2001jan01

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041 qmult 00250 1 1 2 easy memory: nuclear fusion defined

Extra keywords: CK-261,266 Sun-question

36. Nuclear fusion is the _____ bonding of nuclei to form _____ nuclei.

a) chemical; larger b) nuclear; larger c) nuclear; smaller d) chemical; smaller e) gravitational; smaller

SUGGESTED ANSWER: (b)

Wrong answers:

e) This is fission, not fusion.

Redaction: Jeffery, 2001jan01

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041 qmult 00270 2 4 3 moderate deducto-memory: H fusion mass loss

Extra keywords: Sun-question

37. In stellar hydrogen fusion to helium, the rest mass energy of the products is _____ less than that of the reactants. The missing rest mass energy went into _____.

a) 70 %; heat energy b) 170 %; magnetic field energy c) 0.7 %; heat energy d) 70 %; magnetic field energy e) 0 %; chemical binding energy

SUGGESTED ANSWER: (c)

Wrong answers:

e) As Lurch would say: "Aaaarh."

Redaction: Jeffery, 2001jan01

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041 qmult 00280 1 3 2 easy math: E=mc**2 calculation 1 kg

Extra keywords: Sun-question

38. 1 kg of matter is equivalent to how much energy? Recall that the speed of light is 3.00×10^8 m/s.

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

SUGGESTED ANSWER: (b) Everyone must remember $E = mc^2$. We note that 1 megaton TNT yields 4.16×10^{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, 2001jan01

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041 qmult 00300 1 1 2 easy memory: MS hydrogen burning I

Extra keywords: Sun-question

39. The energy emitted as electromagnetic energy from main sequence stars is supplied by the:

a) nuclear burning of helium to hydrogen. b) nuclear burning of hydrogen to helium. c) nuclear burning of hydrogen to carbon. d) nuclear burning of helium to carbon. e) chemical burning of hydrogen to carbon.

SUGGESTED ANSWER: (b)

Wrong answers:
a) Wrong way around.

Redaction: Jeffery, 2001jan01

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041 qmult 00320 1 1 2 easy memory: thermonuclear reactions in star cores
Extra keywords: CK-267-12 Sun-question

40. Thermonuclear reactions happen only in a star's core (which for the Sun is the region within about 0.25 solar radii of the Sun's center) because only there is it _____ enough.

a) cold and dilute b) hot and dense c) hot and dilute d) bland and fragile e) dirty and smudgy

SUGGESTED ANSWER: (b) See CK-263 and Cox-342.

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

Redaction: Jeffery, 2001jan01

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041 qmult 00330 1 1 1 easy memory: nuclear burning on star surface I
Extra keywords: CK-322-4 Sun-question

41. Why don't thermonuclear reactions happen on the surface of main sequence stars?

a) Not hot and not dense enough. b) Too hot and too dense. c) Too green. d) Too bad. e) Too late.

SUGGESTED ANSWER: (a)

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

Redaction: Jeffery, 2001jan01

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041 qmult 00400 1 5 2 easy thinking: detailed star modeling I
Extra keywords: Sun-question

42. In addition to observations of a star and physics theory, in order to understand the star in detail one needs:

a) a few calculations on a scrap of paper. b) detailed computer modeling. c) experiments on Sun-size gas balls. d) nothing else at all. e) luck.

SUGGESTED ANSWER: (a)

Wrong answers:
c) It would be nice if one could do such experiments but they are not needed and one would still have to do modeling anyway.
e) As Lurch would say: "Aaaarh."

Redaction: Jeffery, 2001jan01

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041 qmult 00420 1 4 3 easy deducto-memory: star model described
Extra keywords: CK-267-11 Sun-question

43. "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

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041 qmult 00500 1 4 3 easy deducto-memory: hydrostatic equilibrium
Extra keywords: Sun-question

44. 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

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041 qmult 00520 1 1 2 easy memory: star pressure support
Extra keywords: CK-261, Sun-question

45. Main sequence stars of low mass are mainly supported against collapse ($\gtrsim 90$

    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

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041 qmult 00610 1 5 3 easy thinking: radiative transfer everyday
Extra keywords: CK-267-10, Sun-question

46. An everyday example of heat transfer by radiative transport (or radiative transfer) is

a) boiling water in a pan. b) a spoon in boiling water growing warm. c) sunlight warming. d) a refrigerator cooling. e) a dog barking.

SUGGESTED ANSWER: (c)

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

Redaction: Jeffery, 2001jan01

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041 qmult 00710 1 4 2 easy deducto-memory: convection described
Extra keywords: CK-267-10, Sun-question

47. In convection (with downward being the direction of gravity):

a) hot blobs rise and cold blobs rise too. b) hot blobs rise and cold blobs sink. c) hot and cold blobs both sink. d) hot and cold blobs don't form. e) hot and cold blobs madly try to consume the universe.

SUGGESTED ANSWER: (b) This is energy transfer by EMR.

Wrong answers:
e) We all remember that classic Steve MacQueen flick *The Blob*.

Redaction: Jeffery, 2001jan01

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041 qmult 00730 2 1 4 moderate memory: 3-d hydrodynamic effects
Extra keywords: Sun-question

48. A common reason why some astrophysical systems are described as poorly understood is that these systems involve three-dimensional hydrodynamic effects (e.g., convection).

a) Three-dimensional hydrodyamics cannot be **ACCURATELY COMPUTATIONALLY TREATED** at all.
b) Three-dimensional hydrodyamics cannot be **TREATED EVEN QUALITATIVELY**.
c) Three-dimensional hydrodyamics can **ALWAYS** be understood qualitatively and this allows us to **ALWAYS** predict three-dimensional hydrodynamical phenomena, just not their magnitude. Accurate computations of three-dimensional hydrodynamic effects, however, are only possible in some cases. For example, when **electromagnetic effects** are present, they actually simplify three-dimensional hydrodynamic effects and allow accurate computations in all cases.
d) Three-dimensional hydrodyamics can **OFTEN** be understood qualitatively and this **SOMETIMES** allows us to predict three-dimensional hydrodynamical phenomena. Accurate computations of three-dimensional hydrodynamic effects are also possible in some cases.
e) Three-dimensional hydrodyamics can **OFTEN** be understood qualitatively and this **SOMETIMES** allows us to predict three-dimensional hydrodynamical phenomena. Accurate computations of three-dimensional hydrodynamic effects are also possible in some cases. For example, when **ELECTROMAGNETIC EFFECTS** are present, they actually simplify three-dimensional hydrodynamic effects and allow accurate computations in all cases. Maybe someday all three-dimensional hydrodynamic effects will be accurately calculable.

SUGGESTED ANSWER: (d)

Wrong answers:
a) Nope. They can be treated computationally sometimes: sometimes accurately, often less so.
b) Qualitative understanding is often possible, at least by analogy to experimentally studied systems or simplified computational models.

c) No they can't always be understood qualitatively: at least not in the sense of being able to predict what will happen. More often what happens is qualitatively understandable in the sense that we can see how it could be so, but without have seen it, wouldn't have been able to predict that it would be so. Of course, sometimes, a phenomena is totally mysterious.
e) This is all right, except that electromagnetic effects usually complicate not simplify a 3-d problem.

Redaction: Jeffery, 2001jan01

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041 qmult 01000 2 4 3 moderate deducto-memory: main sequence evolution
Extra keywords: Sun-question

49. During a star's **MAIN SEQUENCE LIFE**, the star is relatively unchanging. But, of course, it is actually changing slowly on the road to its demise. The key change is that:

a) carbon dioxide (CO_2) is being expelled by the star's wind.
b) molecular nitrogen (N_2) is being expelled by the star's wind.
c) hydrogen fuel is being exhausted in its core.
d) hydrogen fuel is being exhausted on its surface.
e) helium fuel is being exhausted in its core.

SUGGESTED ANSWER: (c)

Wrong answers:
e) Helium fuel is burnt during some post-main-sequence phases.

Redaction: Jeffery, 2001jan01

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041 qmult 01010 1 1 4 easy memory: main sequence longest phase
Extra keywords: CK-322-6, Sun-question

50. Most nuclear-burning stars are main sequence stars. The reason for this is that the main sequence phase of the nuclear-burning life of star of any mass is the:

a) shortest phase. b) most popular phase. c) wettest phase. d) longest phase. e) darnest phase.

SUGGESTED ANSWER: (d) See CK-311

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

Redaction: Jeffery, 2001jan01

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041 qmult 01030 2 4 4 mod. deducto-memory: early Sun luminosity
Extra keywords: Sun-question

51. At the time the Sun first became a main sequence star, its luminosity was probably _____ than at present.

a) 30 % greater b) 100 % greater c) 50 times greater d) 30 % lower e) 100 % lower

SUGGESTED ANSWER: (d)

Wrong answers:
e) Now this doesn't seem very likely does it.

Redaction: Jeffery, 2001jan01