

UNIVERSITY OF CALIFORNIA, SANTA BARBARA
Department of Physics

Astronomy 1
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Winter 2009

FINAL EXAM
March 18, 2009

VERSION A

Make sure that the person on either side of you has a different colored exam from yours. Answer each question by filling in the appropriate block on your scantron form, using a No. 2 pencil only. For each question give the one best answer. There is no penalty for guessing, so be sure you give an answer for every question.

Be absolutely sure that you print your name on your scantron form. To avoid possible mistakes, we suggest that you don't fill in the scantron form until you have decided on your answers to all questions.

This is a closed book, closed notes exam. You may, however, use a calculator. Do not start until told to do so. **Most importantly, note the version of your exam at the top of the scantron form.**

If you wish to receive your exam back in a publicly accessible place, be sure to **SIGN** your scantron form.

Some formulae of possible interest:

Conversion of mass to energy: $E = mc^2$, where $c = 3 \times 10^8$ m/sec

Doppler effect: $\frac{v}{c} = \frac{\Delta\lambda}{\lambda_0}$

Energy of a photon: $E = h\nu$, where $h = 6.6 \times 10^{-34}$ J \times s

Kepler's Third Law: $P^2 \propto a^3$

Total radiation flux of blackbody per unit area per unit time: $F = \sigma T^4$ ("Stefan-Boltzmann Law")

Peak of blackbody spectrum: $\lambda_{\max} = 2.9 \times 10^{-3} \text{mK} / T$ ("Wien's Law")

Newton's Law of Universal Gravitation: $F_g = G \frac{m_1 m_2}{d^2}$, where $G = 6.67 \times 10^{-11} \text{Nm}^2/\text{kg}^2$ in our "mks" metric units

Surface area of a sphere = $4\pi R^2$; Volume of a sphere $4\pi / 3 R^3$

1m = 10^6 microns = 10^9 nm = 10^{10} Å

$v\lambda = c$

$c = 3 \times 10^8$ m/sec

$F = ma$

One light year $\approx 1.0 \times 10^{16}$ m; One pc $\approx 3 \times 10^{16}$ m

Distance to Moon: 400,000 km or 240,000 mi

1 astronomical unit, the distance from the Sun to Earth, is ~ 93 million miles or 150 million km

$h = 6.62 \times 10^{-34}$ Joule-seconds

Small angle formula: $D \approx \alpha d / 200,000$ for α in arcseconds; d is the distance

$\sigma = 5.7 \times 10^{-8} \text{W/m}^2\text{K}^4$ in our "mks" metric units

Luminosity = (surface area A) \times (Energy Flux per unit area F).

TRUE/FALSE (mark as choice A or B, respectively)

1. The Cosmic Microwave Background has a blackbody spectrum.
2. Under exotic conditions, intuition sometimes fails, e.g. speed of light is the same for all observers.
3. Ozone depletion may have stabilized because of an international agreement to reduce emission of certain industrial chemicals called chlorofluorocarbons.
4. The Sun appears to circle the Celestial Sphere in one year because the Earth is circling the Sun. The Sun's apparent path is called the horizon.
5. Jovian planets have densities similar to that of water, and we know in fact that they are mostly made of water.
6. Red giant stars are powered by hydrogen burning in a shell surrounding a core, which has been depleted of hydrogen.
7. A good example of a positive feedback effect in global warming is that melting sea ice causes a decrease in the Earth's albedo, meaning we absorb more sunlight than ever.
8. Planetary orbits are circles with the Sun in the center.
9. Opaque bodies obey the blackbody laws: the Stefan-Boltzmann Law and Wein's Law.
10. Global warming has slowed because of an international agreement limiting the release of carbon dioxide into the Earth's atmosphere.
11. Old streambeds and other topographic features indicate that Mars once had liquid water on its surface.
12. A THEORY is a pattern in nature thought to have predictive power. The test of a theory is a prediction. That's where pseudo-science fails.
13. While the heavy elements have been cooked-up in stars, several of the light elements and isotopes were made in the first few minutes of the Big Bang.
14. Venus's surface is very hot because it is closer to the Sun than the earth is.

15. A pulsar is
- A. a rapidly rotating neutron star, emitting beams of radio and sometimes x-ray and visible energy.
 - B. a binary star in which matter from one star is falling onto the second star.
 - C. an object at the center of each galaxy, which provides its energy by rapid rotation.
 - D. a pulsating star, in which size, temperature and light intensity vary regularly.
16. Consider two arbitrary distant galaxies, A and B. If galaxy A is twice as far away from us as is galaxy B, then which of the statements listed below would most likely be true?
- A. Galaxy A is four times as bright as galaxy B.
 - B. Galaxy A is twice as bright as galaxy B.
 - C. Galaxy B is twice as bright as galaxy A.
 - D. Galaxy A is moving away from us at twice the speed of galaxy B.
 - E. Galaxy B is moving away from us at twice the speed of galaxy A.
17. Suppose the Universe is 14 billion years old. If we observe a galaxy 10 billion light years away, how old was the Universe at the time the light we see left that galaxy.
- A. 25 billion years
 - B. 14 billion years
 - C. 10 billion years
 - D. 4 billion years
 - E. insufficient information given
18. The Moon's orbital period and its rotation period are the same. Therefore,
- A. any people on the Moon always see the same half of Earth.
 - B. people on Earth always see the same half of the Moon.
 - C. the Moon always rises at midnight.
 - D. people on the Moon would always see a full Earth.
 - E. A and B
19. A main-sequence star ten times more massive than the Sun has a luminosity which is
- A. thousands of times that of the Sun.
 - B. ten times that of the Sun.
 - C. the same as that of the Sun.
 - D. one-tenth ($1/10$) that of the Sun.
 - E. less than one-hundredth ($1/100$) that of the Sun.
20. The bright red clouds surrounding newly-formed massive stars are
- A. planetary nebulae.
 - B. regions composed entirely of dust grains.
 - C. regions of ionized hydrogen.
 - D. supernova remnants.
 - E. not clouds at all, they are the surfaces of red giant stars.

21. The age of the Universe is roughly

- A. 1 million years.
- B. 55 million years.
- C. 4.5 billion years.
- D. 14 billion years.
- E. 15 trillion years.

22. We observe an emission line in the gamma ray spectrum of the Galactic Center. It is due to the process where an electron and its antimatter equivalent annihilate, and produce two photons of (about) equal energy. What is the frequency of the emission? (You need to know that the mass of an ordinary electron or an antimatter electron is approximately 1×10^{-30} kg.)

- A. 9×10^{14} Hz
- B. 4×10^{18} Hz
- C. 1×10^{20} Hz
- D. 3×10^{22} Hz
- E. 2×10^{24} Hz

23. How do red giants of 0.2 solar masses differ from those of 1.0 solar mass?

- A. They are much dimmer.
- B. They are much smaller.
- C. They burn hydrogen in the core rather than in a shell source.
- D. There aren't any of them, so the question is moot.
- E. They are all very old.

24. The fact that virtually all galaxies are receding from us implies that

- A. we are at the center of the Universe.
- B. the Universe is open.
- C. the Universe is closed.
- D. there is a large-scale repulsive force acting to counter gravity.
- E. the Universe is expanding.

25. The altitude (distance above the horizon) of the pole star Polaris, visible from the Earth's northern hemisphere, is approximately equal to

- A. the observer's longitude.
- B. the observer's latitude.
- C. The answer varies greatly, depending on the time of day.
- D. The answer varies greatly, depending on the time of year.

26. The final stage in the evolution of a low-mass star is a
- A. neutron star.
 - B. white dwarf.
 - C. supernova.
 - D. black hole.
 - E. B and C
27. The gravitational acceleration on the Earth's surface is $\sim 10 \text{ m/s}^2$. What would it be on the surface of a planet with the same size, but one-half the mass?
- A. 5 m/s^2
 - B. 10 m/s^2
 - C. 20 m/s^2
 - D. 40 m/s^2
 - E. 2.5 m/s^2
28. Which is false?
- A. All incandescent (ordinary heated wire) light bulbs have very low efficiency.
 - B. Fluorescent bulbs can have much higher efficiency because they do not have to obey Wein's Law.
 - C. It would be dangerous to look directly at a blackbody at 6000 K.
 - D. A nebular with forming stars inside has an emission line spectrum.
29. Suppose Hubble's constant is 50 km/sec/Mpc (this is not the currently accepted value). What would the approximate age of the universe be in this case?
- A. 5.0 billion years
 - B. 14 billion years
 - C. 20 billion years
 - D. 41 billion years
 - E. 61 billion years
30. When the Moon is full, at what time does it rise?
- A. dawn
 - B. noon
 - C. sunset
 - D. midnight
31. Captain Picard wishes to send a message to a Ferenghi ship, which is located behind a large dust cloud. In order to ensure the best possible transmission he sends
- A. ultraviolet light
 - B. green light
 - C. radio waves
 - D. nothing can penetrate a dust cloud

32. Suppose you travel at constant speed to the Galactic Center, 25,000 light years away. Which is false?
- A. If the speed is high enough, you can get to the Galactic Center while still alive.
 - B. If the speed is high enough, you can make this trip and get back to Earth before summer break.
 - C. If the speed is high it will seem to you that the distance to the Galactic Center is a lot less than 25,000 light years.
 - D. If one twin lives on a neutron star and one lives on Earth, when they get together again, the one who lived on a neutron star will be the younger of the two (assuming you could survive on a neutron star).
33. How do we know the Crab Nebula is a supernova remnant rather than, say, a star-forming region or a planetary nebula?
- A. It is at the location of a “New Star” in Chinese records, 1054 AD.
 - B. It has extremely large Doppler and “proper motion” velocities, the latter approximately consistent with the explosion date.
 - C. It is loaded with heavy elements.
 - D. It has a pulsar (type of neutron star) in the center.
 - E. All of the above.
34. On its way to Earth, the light from a distant quasar passes through a thin, cool cloud of intergalactic gas. What effect does that cloud have on the quasar spectrum we detect from Earth?
- A. It shifts all the frequencies lower (redshift).
 - B. It amplifies the quasar’s apparent brightness.
 - C. It adds some absorption lines.
 - D. It adds broad emission lines.
 - E. Absolutely none.
35. Which is false?
- A. The terrestrial planets have low masses because the rocky elements have low abundances.
 - B. Earth has a substantial natural Greenhouse Effect.
 - C. Given Earth’s gravity and temperature, helium cannot be held in the atmosphere.
 - D. If a giant stopped the Earth in its orbit, it would fall into the Sun.
 - E. All the terrestrial planets show plate tectonics.
36. Which is true?
- A. Fusion of iron produces energy.
 - B. Fission (splitting) of iron produces energy.
 - C. The Sun will eventually develop an iron core.
 - D. Iron has the most mass per nuclear particle of all the elements.
 - E. Iron has the least mass per nuclear particle of all the elements.

37. An astronaut is floating freely in space. If s/he were to push on a nearby spaceship, what would happen?
- A. Both the astronaut and the spaceship would move, but in opposite directions.
 - B. Both the astronaut and the spaceship would move in the direction of the push.
 - C. The astronaut would move, but the spaceship would not.
 - D. Insufficient information has been given.
38. The Sun is located roughly
- A. at the center of the Milky Way.
 - B. at the center of the Andromeda Galaxy.
 - C. 25,000 light years above (out of) the plane (disk) of the Milky Way.
 - D. 25,000 light years from the center of the Milky Way, in its plane.
 - E. outside any galaxy, i.e., in intergalactic space.
39. What is the distance to Sirius? The parallax is 0.337 arcsec.
- A. 0.377 pc
 - B. 2.65 pc
 - C. 4.0 pc
 - D. 9.50 pc
 - E. 22 pc
40. What happens to the energy of the starlight absorbed by interstellar dust grains?
- A. It simply ceases to exist.
 - B. Energy cannot disappear. It must go into heating the dust.
 - C. It is re-radiated by the dust as infrared light.
 - D. Starlight carries no energy, so the question is meaningless.
 - E. B and C
41. Very old stars such as those in globular clusters
- A. are found in spiral arms.
 - B. are sometimes massive and blue.
 - C. have very low heavy element content in their atmospheres.
 - D. are no longer directly observable.
42. When one kilogram of hydrogen is converted into helium in the center of the Sun, the amount of energy produced is about (Hint: remember that not all of the mass of hydrogen is converted into energy)
- A. 6×10^{14} J
 - B. 4×10^{12} J
 - C. 2×10^{10} J
 - D. It depends on whether the pp or CNO cycle is involved.

43. A forming star stops its initial contraction
- A. when it gets to the main sequence.
 - B. when hydrogen burning starts.
 - C. when helium burning starts.
 - D. A and C
 - E. A and B
44. The Sun and Moon both subtend an angle of $\frac{1}{2}$ degree, as seen from Earth. The Sun is however 400 times farther away. How does the size of the Sun compare with the size of the Moon?
- A. about the same
 - B. 6.3 times larger
 - C. 20 times larger
 - D. 400 times larger
 - E. 160,000 times larger
45. About how many degrees does the Moon move on the Celestial Sphere each day?
- A. 1
 - B. 12
 - C. 30
 - D. 365
46. The Orion nebula consists of a hot, transparent gas. The spectrum from this region consists primarily of
- A. a continuum of emission over the visible wavelengths (i.e., emission at all wavelengths in the visible part of the spectrum).
 - B. a continuum of emission over the visible with absorption lines at a few specific wavelengths.
 - C. emission lines at a few specific wavelengths.
 - D. a bright red continuum (i.e., emission at all wavelengths in the red part of the spectrum).
 - E. a bright blue continuum (i.e., emission at all wavelengths in the blue part of the spectrum).
47. Which is false?
- A. Ozone depletion is making the atmosphere more transparent to ultraviolet light.
 - B. Carbon dioxide production is making the atmosphere more transparent to infrared light.
 - C. The surface of Mars is sterilized by ultraviolet light.
 - D. The surface of Venus is extremely hot because its atmosphere traps infrared light.
 - E. The Earth's crust has about as much carbon dioxide as the atmosphere of Venus.
48. Pluto's average distance from the Sun is 4.0 AU. What is the orbital period?
- A. 12 years
 - B. 40 years
 - C. 160 years
 - D. 240 years
 - E. 480 years

49. A galaxy is discovered with a recessional velocity of 7000 km/s. Assuming Hubble's constant is 70 km/sec/Mpc, what is the distance to the galaxy?
- A. 7000 km
 - B. 7000 pc
 - C. 6600 light years
 - D. 100 Mpc
 - E. You can't tell without knowing the age of the galaxy.
50. The luminosity of an object is defined as
- A. the light output per square meter on its surface area.
 - B. the peak of the blackbody curve for the surface temperature of the object.
 - C. the amount of light striking one square meter of a collector (telescope) as observed here on Earth.
 - D. The total light output of an object per second
51. The Greenhouse Effect occurs because
- A. a planetary atmosphere absorbs solar radiation.
 - B. a planetary atmosphere reflects solar radiation.
 - C. a planetary atmosphere absorbs the planet's own radiation.
 - D. vegetation preferentially absorbs green light.
52. Which of the following is false regarding the Big Bang Theory?
- A. It explains the production of the light elements, such as hydrogen, helium and lithium.
 - B. It explains the production of the heavy elements, such as carbon, oxygen and iron.
 - C. It explains the Cosmic Microwave Background radiation.
 - D. It incorporates Einstein's theory of gravity.
 - E. It explains the Hubble Law.
53. A supernova can be produced by
- A. the collapse of the core of a very massive star.
 - B. the birth of a main-sequence star.
 - C. a pulsar.
 - D. nuclear reactions on the surface of a white dwarf.
 - E. a low-mass main-sequence star.
54. Which list is in order of increasing photon energy?
- A. x-rays, ultraviolet, optical
 - B. radio, gamma rays, infrared
 - C. optical, ultraviolet, infrared
 - D. gamma rays, infrared, radio
 - E. radio, infrared, x-ray

55. What is the wavelength of an electromagnetic wave with a frequency of 10^{10} Hz?
- A. 0.3 m
 - B. 3×10^{19} m
 - C. 0.03 m
 - D. 3×10^{-16} m
 - E. 3×10^{-7} m
56. What determines the temperature of a rocky planet without an atmosphere?
- A. chemical reactions in the crust
 - B. its size
 - C. the sunlight absorbed and the infrared light emitted
 - D. the density
57. Immediately after leaving the main sequence, a star becomes a
- A. protostar.
 - B. black hole.
 - C. supernova.
 - D. planetary nebula.
 - E. red giant.
58. How long does night last for an observer on the Moon, on average?
- A. 12 hours
 - B. 2 weeks
 - C. one month
 - D. forever, if the observer is on the “dark side”
59. The Great Red Spot is
- A. the colored polar cap of Jupiter.
 - B. a temporary storm in Jupiter’s atmosphere, last a few months.
 - C. the top of a massive mountain penetrating through Jupiter’s clouds.
 - D. a large, long-lived storm system in Jupiter’s atmosphere.
60. The nearest powerful quasar, 3C273, has a flux of 1.9×10^{-12} Joules per second per square meter and a distance of 630 million parsecs. What is the luminosity?
- A. $L = 9 \times 10^{36}$ Watts, or $\sim 2 \times 10^{10}$ as much as the Sun
 - B. $L = 4 \times 10^{37}$ Watts, or $\sim 1 \times 10^{11}$ as much as the Sun
 - C. $L = 9 \times 10^{39}$ Watts, or $\sim 2 \times 10^{13}$ as much as the Sun
 - D. $L = 4 \times 10^{41}$ Watts, or $\sim 1 \times 10^{15}$ as much as the Sun
 - E. $L = 4 \times 10^{42}$ Watts, or $\sim 1 \times 10^{16}$ as much as the Sun

61. Which is false?

- A. The Moon must be full at the time of a solar eclipse.
- B. The Moon must be full at the time of a lunar eclipse.
- C. The “inferior” planets Venus and Mercury always stay in the general direction of the Sun.
- D. Retrograde motion of the superior planets is an illusion resulting from Earth’s own motion.
- E. The Sun is at one focus of each planetary orbit. Both the other focus and the center of the orbit are empty.

62. Which is false?

- A. Light energy seems to come in discrete packets proportional to the frequency of the light.
- B. A blackbody absorbs all light striking it.
- C. The hotter solid object blackbody emits more light at all frequencies than a cooler one.
- D. The same gas cloud can show an absorption line spectrum to one observer and an emission line spectrum to another.
- E. If the Sun were twice as far from Earth, it would appear only half as bright.

63. About how many degrees does the Sun move on the Celestial Sphere each day?

- A. 1
- B. 12
- C. 30
- D. 365

64. Which is false?

- A. The planets move fastest when nearest the Sun.
- B. The planets stay fairly near the ecliptic on the Celestial Sphere.
- C. If your spaceship is far from any interstellar gas or other matter, and far from any gravitating body, it will just drift at fixed velocity, and no control is possible.
- D. Gravitational acceleration is independent of mass, showing that gravitational force must be proportional to mass.
- E. Although the Moon rotates on its axis once a month, this does not cause Earth to rise and set once a month as seen from the Moon.

65. What is the closest the Sun ever gets to the zenith (the point directly overhead) from Santa Barbara? Our latitude is about +34 degrees.

- A. 34 degrees away
- B. 56 degrees away
- C. 23 degrees away
- D. 11 degrees away
- E. it can get right overhead on the summer solstice

66. If the Universe is 14 billion years old, roughly speaking, the farthest presently observable object in the Universe cannot be
- A. more distant than 10 billion light years.
 - B. more distant than 14 billion light years.
 - C. more distant than 20 billion AUs (astronomical units).
 - D. more distant than 10 billion AUs.
 - E. arbitrarily large – unlimited – distances as long as we have a telescope large enough.
67. Binary stars are particularly important for determining what aspect of stars?
- A. Temperature
 - B. Luminosity
 - C. Distance
 - D. Radius
 - E. Mass
68. The globular clusters are mostly located on one half of the celestial sphere. This means that
- A. the other half of the celestial sphere is obscured by dust.
 - B. the globular clusters mostly reside at one side of the Milky Way.
 - C. the globular clusters are centered on the Milky Way galaxy, but the Sun is off-center.
 - D. The explanation for this fact is still unknown.
69. Energy can be produced by
- A. fission (splitting) of light elements.
 - B. fusion of light elements.
 - C. fusion of heavy elements.
 - D. A and B
 - E. B and C
70. A white dwarf with ten times the Sun's mass
- A. would be very small.
 - B. would be very dense.
 - C. would be made mostly of heavy elements.
 - D. all of the above.
71. The motions of large portions of the Earth's surface, the "plates", are caused by
- A. flexing of the surface due to solar heating and nighttime cooling.
 - B. the varying pressure of the Earth's atmosphere, both daily and seasonally.
 - C. tidal flow in oceanic waters.
 - D. convective flow of matter in the Earth's interior.

72. The Chandrasekhar limit is

- A. the radius of a black hole's event horizon.
- B. the maximum mass of a neutron star.
- C. the maximum mass that can be supported by electron degeneracy pressure.
- D. the maximum mass of a black hole.

73. Which statement is false?

- E. Earth has as much carbon dioxide as Venus, but ours is mostly in the crust rather than in the atmosphere.
- F. If Earth's carbon dioxide was liberated, humans exposed on the surface would probably boil and vaporize because of the increased strength of the Greenhouse Effect.
- G. We can calculate the result of the release of greenhouse gases by human activity with good precision and high reliability.
- H. There is a substantial natural Greenhouse Effect on Earth.
- I. In a separate problem, largely unrelated to the Greenhouse Effect, chlorofluorocarbon chemicals created by humans seem to be reducing the ozone layer, allowing cancer-causing ultraviolet light to reach Earth's surface in greater quantities.

74. The principle nuclear reaction that occurs in main-sequence stars is

- A. hydrogen being converted to helium.
- B. helium being converted to hydrogen.
- C. hydrogen being converted to carbon.
- D. helium being converted to carbon.
- E. none of the above.