ASTR 1120-001 Midterm 1

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FIRST MID-TERM EXAM FEBRUARY 16th 2006: Closed books and notes, 1 hour. Please PRINT your name and student ID on the places provided on the scan sheet. ENCODE your student number also on the scan sheet.

Questions 1-10 are TRUE / FALSE, 1 point each. Mark (a) True, (b) False on scan sheet, using a number 2 pencil.

1. Light of low frequencies has long wavelengths. TRUE
2. A photon of blue light has less energy than a photon of red light. FALSE
3. The speed of electromagnetic radiation in a vacuum increases with increasing photon energy. FALSE
4. The amplitude of electromagnetic radiation waves is a measure of the intensity of the radiation. TRUE
5. The Sun is mostly composed of helium. FALSE
6. Fusion of hydrogen nuclei into helium nuclei releases energy. TRUE
7. The rate of nuclear fusion within the Sun varies with the Solar Cycle. FALSE
8. The pressure in the core of the Sun is larger than the pressure near the surface. TRUE
9. A star that appears dim is always further away than a star that appears brighter. FALSE
10. Higher temperature increases the rate of nuclear fusion reactions. TRUE

Questions 11-50 are MULTIPLE CHOICE, 1 point each. Mark scan sheet with letter of the BEST answer, using a number 2 pencil.

11. The frequency of a wave is:

(a) Measured in seconds
(b) The distance between crests of the wave
(c) The distance between troughs of the wave
(d) The number of peaks passing by any point per second
(e) The same for all forms of electromagnetic radiation

12.Sunspots are observed as:

(a) Dark spots in the Solar corona
(b) Bright regions in the Solar corona
(c) Dark spots on the Solar photosphere
(d) Bright regions on the Solar photosphere
(e) Places where no light is emitted by the Sun

13. Nuclear reactions involve much larger energies than chemical reactions because:

(a) Neutrons and protons have a much larger mass than electrons
(b) Neutrons and protons have a smaller mass than electrons
(c) Chemical reactions occur much more quickly than nuclear reactions
(d) The strong nuclear force binds nuclei together more tightly than electromagnetism binds electrons to the nucleus
(e) Gravity is much the weakest of the 4 fundamental forces

14. The lifetime of a star is primarily determined by:

(a) Its chemical composition
(b) The stellar rotation rate
(c) The strength of magnetic fields on the photosphere
(d) Pressure
(e) The stellar mass

15. Infrared radiation with a wavelength of 10 microns (10^{-5} m) has a frequency of 3 x 10^{13} Hz. Given the formula c = f□, radiation with a wavelength of 30 microns has a frequency of:

(a) 10^{13} Hz
(b) 3 x 10^{13} Hz
(c) 9 x 10^{13} Hz
(d) 3 x 10^{16} Hz
(e) 3 x 10^{43} Hz

16. From short to long wavelengths, the correct order of the electromagnetic spectrum is:

(a) Ultraviolet, X-rays, visible, infrared, radio
(b) X-rays, visible, ultraviolet, infrared, radio
(c) Ultraviolet, X-rays, visible, radio, infrared
(d) X-rays, ultraviolet, visible, infrared, radio
(e) Radio, infrared, visible, X-rays, ultraviolet

17. Planetary systems around other stars are hard to detect primarily because:

(a) Dim light from the planet is hard to see against the glare of the star
(b) Jupiter mass planets are extremely rare
(c) Jupiter mass planets are fairly abundant, but often have elliptical orbits around their star
(d) Massive stars are the most common type of star, and these have short lifetimes

18. If energy production in the core of the Sun were suddenly to cease, the result would be:

(a) A rapid collapse of the Sun to form a black hole
(b) A supernova explosion
(c) Very slow contraction of the Sun
(d) Very slow expansion of the Sun
(e) No change for billions of years

19. The energy of a photon is:

(a) Proportional to its wavelength
(b) Proportional to its frequency
(c) Proportional to its speed
(d) Independent of the type of electromagnetic radiation
(e) Higher for X-ray photons than for gamma-ray photons

20. Stars that formed 10 billion years ago with a tenth the mass of the Sun:

(a) All remain on the main sequence today
(b) Have evolved into giants, and subsequently white dwarfs
(c) Have higher core temperatures than the Sun
(d) Produce more neutrinos, per second, than the Sun
(e) Have enriched the galaxy with the products of nuclear reactions

21. The Solar cycle is thought to be caused by:

(a) Sunspots
(b) Solar prominences
(c) Nuclear reactions within the Solar core
(d) A pressure gradient between the core and the photosphere
(e) A combination of magnetic fields and rotation

22. Thermal radiation is the kind of radiation we expect to observe from:

(a) Transparent clouds of gas with no background source
(b) Extremely hot gas clouds
(c) Gas clouds near absolute zero
(d) Neon lamps on earth
(e) Opaque sources such as stars

23. You observe 2 stars and note that star A appears blue while star B appears red. From this, you deduce:

(a) The photosphere of star A is hotter than star B
(b) The photosphere of star B is hotter than star A
(c) Nothing can be deduced about the surface temperature from this observation

24. Which object emits more infrared radiation?

(a) The Earth
(b) The Sun
(c) A star that is the same size as the Sun, but twice as hot
(d) A star that is the same size as the Sun, but cooler
(e) A brown dwarf

25. A thermal spectrum depends upon:

(a) The temperature and density of the emitting source
(b) The temperature and composition of the emitting source
(c) The temperature of the source only
(d) The density of the source only
(e) The composition of the source only

26. A spectrum is a graph of:

(a) Wavelength (on the vertical axis) against frequency (on the horizontal axis)
(b) Intensity (on the vertical axis) against wavelength (on the horizontal axis)
(c) Frequency (on the vertical axis) against wave speed (on the horizontal axis)
(d) Energy (on the vertical axis) against frequency (on the horizontal axis)
(e) Temperature (on the vertical axis) against wavelength (on the horizontal axis)

27. Slow contraction of the Sun can be ruled out as the Sun's main energy source because:

(a) Simple estimates show that the energy would run out after only a few thousand years
(b) The time scale for contraction is about 25 million years - much less than the age of the Earth
(c) Rocks on Earth have been dated as billions of years old
(d) Contraction of a star does not yield any energy
(e) The Sun's size is observed to be constant over time

28. Atomic nuclei are held together by:

(a) Gravity
(b) Repulsive electrostatic forces between the protons and neutrons
(c) Attractive electrostatic forces between the protons and neutrons
(d) Nuclear fusion
(e) The strong nuclear force

29. Which two physical processes balance each other to create the condition known as gravitational equilibrium in stars?

(a) Gravity and an outward pressure gradient
(b) Gravity and electromagnetism
(c) Convection and radiation
(d) Rotation and gravity
(e) The strong nuclear force and the weak nuclear force

30. The Sun is predicted to exhaust the supply of nuclear fuel in its core in about:

(a) 3000 years
(b) 25 million years
(c) 500 million years
(d) 5 billion years
(e) 50 billion years

31. The Sun derives energy today primarily from:

(a) The glow from a very hot plasma
(b) The combining of light elements into heavier ones
(c) The breaking apart of heavy elements into lighter ones
(d) Nuclear fission
(e) Radioactive processes

32. The Sun's luminosity can be measured in:

(a) joules
(b) watts
(c) Newtons
(d) Kilograms
(e) Hertz

33. Neutrinos are difficult to detect because;

(a) They pass through matter with only a small probability of interactions
(b) They travel at the speed of light
(c) They have less energy than photons
(d) They have zero rest mass
(e) Muon neutrinos and tau neutrinos can change into electron neutrinos before reaching Earth

34. Which of the following best describes the current status of the Solar neutrino problem?

(a) It remains a complete mystery
(b) Experiments suggest that the Sun's core must be cooler than previously thought, which reduces the rate of nuclear fusion and the number of neutrinos produced
(c) Experiments suggest that electron neutrinos produced in the core can change into other types before reaching Earth, reducing the observed number of electron neutrinos
(d) Early experiments appear to have been misinterpreted
(e) Neutrinos interact very weakly with water in current detectors

35. Suppose that for some reason the center of the Sun suddenly became hotter. What would happen next?

(a) The rate of nuclear fusion would increase, driving the temperature still higher
(b) An explosion would be triggered due to a runaway nuclear fusion reaction
(c) The core would expand, reducing the pressure and temperature back to their original values
(d) Hydrogen fusion would cease, and the Sun would cool down
(e) The Sun would leave the main sequence and expand to become a red giant star

36. The net result of hydrogen burning (nuclear fusion) in the Sun today is that:

(a) Iron and other heavy elements are synthesized from hydrogen
(b) Helium nuclei are formed, and energy and neutrinos are emitted
(c) Helium nuclei are formed, and energy and neutrinos are absorbed
(d) Individual protons are linked into long chains of protons
(e) Energy is liberated as electrons fall into the ground state of helium atoms

37. Describing the Sun as being in a state of gravitational equilibrium implies:

(a) That the Sun's core is much hotter than the Solar photosphere
(b) That the Sun's mass remains fixed, creating the same gravitational force
(c) That rotation and other forces are not important for the Solar structure
(d) That energy generated in the core leaks to the surface on a long time scale
(e) That there is a balance between the inward pull of gravity and the outward push of pressure

38. A person reads a newspaper while standing 10 feet from a table that has on it a 100 watt unshaded light bulb. Imagine that the person moves so that she is now 20 feet from the table. How many light bulbs would need to be placed on the table to light up the newspaper as brightly as before (see Q42 for formula)?

(a) 1 bulb
(b) 2 bulbs
(c) 4 bulbs
(d) 8 bulbs

39. Every second, the Sun converts about 600,000,000 tons of hydrogen into 596,000,000 tons of helium. The difference of 4,000,000 tons:

(a) Represents mass that is converted into energy and eventually radiated by the Sun
(b) Is lost as neutrinos that escape the Sun without further interaction
(c) Is the mass of heavier elements (such as carbon) formed every second
(d) Causes the Sun to contract
(e) Causes transitions of electrons within atoms of hydrogen in the Solar core

40. Nuclear reactions occur primarily in the Solar core because:

(a) Most of the Sun's mass is in the core
(b) The fraction of hydrogen is greater in the core than near the surface
(c) The regions of the Sun near the surface are convective
(d) The temperature in the core is higher than near the surface
(e) The density in the Solar core is higher than near the surface

41. For most stars, it is *hardest* to accurately determine:

(a) The apparent brightness
(b) The surface temperature
(c) The distance

42. The formula for the apparent brightness of a star is that:

$$\text{apparent brightness} = \frac{\text{luminosity}}{4\pi\,\text{distance}^2}$$

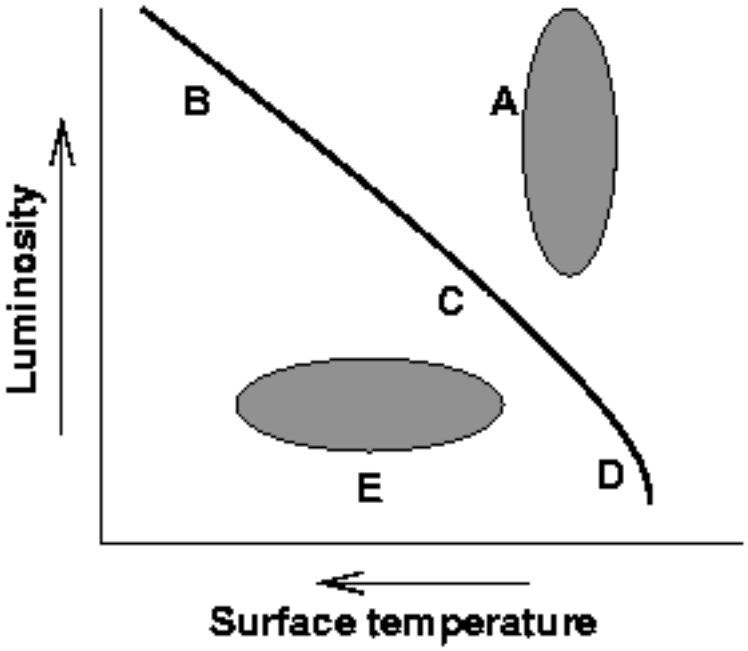
If the star Sirius was 27 light years away rather than 9 light years away, it's apparent brightness would be:

(a) Reduced by a factor of 27
(b) Reduced by a factor of 9
(c) Reduced by a factor of 3
(d) Increased by a factor of 3
(e) Increased by a factor of 9

43. Parallax is:

(a) A way to measure distances to stars
(b) A geometric effect caused by the Earth's motion around the Sun
(c) Difficult to measure for very distant stars
(d) The apparent motion of nearby stars relative to distant ones
(e) All of the above

The next 4 questions all refer to the following schematic Hertzprung-Russell diagram:



44. Where in the diagram (locations A, B, C, D, or E) would you expect to find stars with the highest surface temperatures? B

45. Where would you expect to find the most massive main-sequence stars? B

46. Where would you expect to find stars with the longest main-sequence lifetimes? D

47. Where would you expect to find giant stars? A

48. Nuclear fission of heavy elements is a process that releases energy. From this we can deduce that:

(a) High temperatures are required for nuclear fission to proceed
(b) The product nuclei must have a higher mass than the original nucleus that fissions
(c) The product nuclei must have a lower mass than the original nucleus that fissions
(d) The product nuclei must contain a larger proportion of neutrons than the original nucleus

49. Collisions between atoms in a gas become more violent when:

(a) The density is reduced
(b) The density is increased
(c) The temperature is reduced
(d) The temperature is increased

50. The type of star most useful for the observational determination of stellar masses is:

(a) A white dwarf
(b) An eclipsing binary star system
(c) A red giant
(d) A star with a rapid rotation rate
(e) A magnetically active star similar to our Sun