Astronomy 103 – Midterm 2 – October 29, 2014

Instructions:

No books, notes or calculator are allowed. You have 50 minutes to complete the exam, and please do not turn to the next page until instructed to do so.

You may find the following information helpful:

- 1 AU $= 3 \times 10^8$ km
- speed of light $c = 3 \times 10^5$ km/s
- Kepler's 3rd law:

  $$a^3 = P^2$$

  with the period P in years and semi-major axis a in AU.
- Newton's law of gravity:

  $$F = \frac{GMm}{r^2}$$

- Peak wavelength and temperature of blackbody radiation:

  $$\lambda = \frac{3 \times 10^6}{T} \text{ nm}$$

  with wavelength λ in nm (1 nm = 10^{-9} m) and temperature T in Kelvin.
- Relationship between frequency f and wavelength λ of light:

  $$\lambda = \frac{c}{f}$$

- Conversion of mass into energy: $E = mc^2$
- Relationship between brightness B and distance d:

  $$B_2 = B_1 \times \frac{d_1^2}{d_2^2}$$

- Relationship between luminosity L, temperature T and radius R of stars:

  $$L = 4\pi\sigma T^4 R^2$$

  where $4\pi\sigma$ are constants.

1. Light of which of the following kinds is observed by earthbound telescopes?

   a) radio waves and visible light
   b) x-rays and gamma rays
   c) gamma rays and radio waves
   d) visible light and x-rays

2. The main advantage of the Hubble Space Telescope compared to telescopes on Earth is:

   a) friendly aliens help out when it has problems
   b) it avoids atmospheric turbulence
   c) it can detect radio waves
   d) it can detect sound waves that do not reach the Earth

3. Radio telescopes are large in part to improve their resolution, which is poor because of the long wavelengths at which they are used to observe the skies.

   a) True
   b) False

4. Why are satellites used to detect x-rays?

   a) space-based detectors are more sensitive
   b) they avoid atmospheric turbulence
   c) x-rays are absorbed by the Earth's atmosphere
   d) to avoid interference from x-ray sources on Earth

5. A gamma-ray telescope has the same design as a telescope used to observe visible light.

   a) True
   b) False

6. The Herschel Infrared Space Telescope is stationed far from earth because

   a) This increases the telescope's field of view
   b) The telescope is sensitive to electromagnetic interference from terrestrial radio stations
   c) Doing so avoids the obscuring effects of dust close to the ground.
   d) Earth is a heat source and the telescope must be kept very cold.

7. Sunspots appear dark because they are hotter than the surrounding gas of the photosphere.

   a) True
   b) False

8. About how hot is the Sun's photosphere?

   a) 3K
   b) 300 K
   c) 3000 K
   d) 6000 K
   e) 10,000 K

9. The visible light we see from the Sun comes from what part of the Sun?

   a) photosphere
   b) corona
   c) chromosphere
   d) core

10. The sun rotates

    a) fastest near the equator
    b) fastest near the poles
    c) with the same speed at all latitudes
    d) not at all.

11. What is the most abundant element in the Sun?

    a) hydrogen
    b) helium
    c) carbon
    d) oxygen
    e) iron

12. The Sun is a stable star in which

    a) the rate of fusion equals the rate of fission
    b) the rate at which energy is emitted by the core is equal to the rate at which energy is absorbed in the corona
    c) radiation and convection balance one another
    d) gravity balances the force from pressure

13. How many times more massive is the Sun than the Earth?

a) 100
b) 300,000
c) 100 million

14. The Sun's energy is produced by the fusion of

a) hydrogen and oxygen to water
b) carbon to iron
c) helium to carbon
d) oxygen to iron
e) hydrogen to helium

15. The density of the Sun is closest to that of which of the objects listed below?

a) an ice cube
b) the Earth
c) an asteroid
d) the Earth's atmosphere

16. Compared to the Sun's corona, its photosphere is

a) denser and hotter
b) denser and cooler
c) less dense and hotter
d) less dense and cooler

17. When hydrogen fuses to helium, what fraction of its mass changes to energy?

a) 100%
b) 70%
c) 50%
d) 5%
e) 0.7%

18. If 10 kg of mass is changed entirely into energy, how much energy is produced?

a) 10 watt-seconds
b) 3 x 10^{8} watt-seconds
c) 3 x 10^{16} watt-seconds
d) 9 x 10^{16} watt-seconds
e) 9 x 10^{17} watt-seconds

19. If the luminosity of a star is 9.0×10^{26} watts, how much mass does it change to energy each second?

    a) 3 x 10^{8} kg
    b) 1 x 10^{10} kg
    c) 9 x 10^{10} kg
    d) 3 x 10^{18} kg
    e) 9 x 10^{18} kg

20. Which of the following lists gives the spectral types of stars in order from the type corresponding to stars with the hottest surfaces to the type corresponding to stars with the coolest surfaces?

    a) F, B, G, O, M
    b) A, B, F, G, O
    c) O, B, F, G, M
    d) K, M, F, G, B
    e) B, G, F, M, K

21. Star A appears brighter than star B, as seen from Earth. Therefore, start A must be closer to Earth than star B.

    a) True
    b) False

22. Stars with cool surfaces can be very luminous if they are very

    a) small
    b) hot
    c) large
    d) close to our solar system

23. Which two of the following need to be measured in order to determine the luminosity of a star?

    a) apparent brightness and temperature
    b) temperature and mass
    c) distance and apparent brightness
    d) mass and distance

24. Once the luminosity of a star is known, what has to be measured in order to find the star's radius?

    a) parallax angle to find distance
    b) color to find distance
    c) color to find surface temperature
    d) parallax angle to find surface temperature

25. About what fraction of stars are in binary systems?

    a) 1/10
    b) 1/2
    c) 9/10

26. What two physical characteristics of stars are related by an H-R diagram?

    a) mass and luminosity
    b) luminosity and surface temperature
    c) mass and surface temperature
    d) mass and radius
    e) luminosity and radius

27. About what fraction of stars are on the main sequence?

    a) less than 10%
    b) about 50%
    c) about 90%

28. If the Sun had a cooler surface, it would be

    a) bluer
    b) redder
    c) there would be no difference in its color

29. From a distance of 1 parsec, the angular size (radius) of Earth's orbit would be

    a) 1 arc second
    b) 1 degree
    c) 2 degrees
    d) impossible to determine

30. The planets Londinium and Bellerophon orbit a star called the White Sun. Londinium is 1 AU from the star, and Bellerophon is 10 AU away. The brightness of light from the White Sun on Londinium is about 100 watt/meter^2. What is the brightness of light from the White Sun on Bellerophon?

    a) 1 watt/meter^2
    b) 10 watt/meter^2
    c) 1000 watt/meter^2
    d) 10,000 watt/meter^2

31. Compared to a main-sequence star of type G, a main-sequence star of type B is:

    a) hotter and less massive
    b) hotter and more massive
    c) cooler and less massive
    d) cooler and more massive

32. Stars of spectral class M do not show strong lines of hydrogen in their spectra because

    a) they contain very little hydrogen
    b) their surfaces are so cool that most hydrogen is in the ground state
    c) their surfaces are so hot that most hydrogen is ionized elements
    d) the hydrogen lines are swamped by even stronger lines of other elements

33. What type of star is the Sun?

    a) A
    b) B
    c) F
    d) G
    e) O

34. You observe two stars in the sky. Star A is a spectral class O supergiant, star B is a spectral class O white dwarf. What can you say about their temperatures?

    a) A is hotter than B
    b) B is hotter than A
    c) A and B have approximately the same temperature
    d) We do not have enough information to derive their temperatures.

35. When visible light from a star passes through interstellar dust, the light

    a) ionizes the dust, which then emits blue and ultraviolet light
    b) is dimmed and becomes bluer
    c) is dimmed and reddened
    d) primarily excites electrons in the silicon atoms of the dust. We observe ultraviolet light when the electrons fall back to their ground state.
    e) is Doppler shifted

36. Two clouds of interstellar gas contract to form stars. Suppose that no mass is lost in the contraction and that when they stop contracting, cloud A is a type A star and cloud K is a type K star. Compared to cloud A, cloud K has

    a) the same mass and the same percentage of hydrogen
    b) a smaller percentage of hydrogen
    c) a larger percentage of hydrogen
    d) more mass
    e) less mass

37. Two clouds of interstellar gas contract to form stars. Suppose that no mass is lost in the contraction and that when they stop contracting, cloud A is a type A star and cloud K is a type K star. What stops the contraction of each star?

    a) Cloud A is stopped by fusion of helium to carbon and cloud K is stopped by fusion of hydrogen to helium
    b) Cloud K is stopped by fusion of helium to carbon and cloud A is stopped by fusion of hydrogen to helium
    c) Both clouds are stopped by fusion of hydrogen to helium
    d) Both clouds are stopped by fusion of helium to carbon
    e) None of these answers is even remotely related to what happens in the formation of stars.

38. A main-sequence star with a mass of 15 times the mass of the Sun has a lifetime that is

    a) much longer than the Sun's.
    b) much shorter than the Sun's.
    c) about the same as the Sun's.

39. It takes less and less time to fuse heavier and heavier elements inside a highmass star.

    a) True
    b) False

40. Star formation requires a sufficient amount of . . . . . to begin.

    a) Hot gas with millions of degrees K
    b) Cold gas with temperatures of tens of degrees K
    c) Asteroid collisions
    d) Emission from emission nebulae
    e) Ionizing radiation

41. What is the next stage in the Sun's evolution?

    a) neutron star
    b) T-Tauri star
    c) white dwarf
    d) type F main-sequence star
    e) red giant

42. Most of the nitrogen on Earth was

    a) formed in a supernova
    b) formed in a star that later exploded in a supernova
    c) formed in a planetary nebula
    d) formed in a star that then lost its outer envelope in a planetary nebula

43. In a core-collapse supernova, the outer part of the core rebounds from the inner, high-density core, destroying the entire outer part of the star.

    a) True
    b) False

44. A nova is a sudden outburst of light coming from an old main sequence star.

    a) True
    b) False

45. One billion years from now the Sun will be a

    a) red giant
    b) main-sequence star
    c) white dwarf
    d) none of the above

46. Match the phases of stellar evolution listed below (1-4) to the appropriate energy generating processes (A-D).

1 Contraction of the core and fusion of hydrogen to helium in a shell
2 Fusion of helium to carbon in the core
3 Contraction of the entire star
4 Fusion of hydrogen to helium in the core

A The energy source for a star just after the helium flash.
B The energy source of a star in its first red-giant stage.
C The energy source of a main sequence star.
D The energy source of a protostar, before it has reached the main sequence.

a) 1 and B, 2 and D, 3 and C, 4 and A
b) 1 and A, 2 and B, 3 and D, 4 and C
c) 1 and D, 2 and A, 3 and C, 4 and B
d) 1 and C, 2 and B, 3 and A, 4 and D
e) 1 and B, 2 and A, 3 and D, 4 and C

47. Put the following stages in a star's evolution in chronological order from first to last:

A contraction of a gas cloud
B main-sequence star
C ejection of a planetary nebula
D first red giant stage
E fusion of helium to carbon in the core

a) C, A, B, E, D
b) A, D, B, E, C
c) B, A, C, E, D
d) A, B, D, E, C
e) A, B, C, D, E

48. What is the upper limit on the mass of a white dwarf?

a) 0.08 solar masses
b) 0.5 solar masses
c) 1.4 solar masses
d) 10 solar masses

49. Match the descriptions below to their names:

A Type I supernova
B Nova
C Planetary nebula
D Type II supernova

1 The ejected outer part of a star whose core becomes a white dwarf.
2 The explosion that results from hydrogen from a companion star falling onto a white dwarf and suddenly fusing to helium when it gets hot enough to ignite.
3 The explosion that results from the gravitational collapse of the iron core of a massive star when it approaches its upper mass limit.
4 The explosion that results from the gravitational collapse of a white dwarf when it approaches or reaches its upper mass limit.

a) 1 and C, 2 and B, 3 and D, 4 and A
b) 1 and A, 2 and B, 3 and D, 4 and C
c) 1 and D, 2 and A, 3 and C, 4 and B
d) 1 and C, 2 and B, 3 and A, 4 and D
e) 1 and B, 2 and A, 3 and D, 4 and C

50. What ages does a star cluster have in which all stars have masses similar to or less than the mass of our Sun?

a) A large age of many billions of years
b) A very young age of at most a few millions of years
c) Each star has a different age, so we can not tell the age of the cluster