Astronomy SSSS 2016

Type Ia Supernovae & Stellar Evolution

School Name: _____

Team #: _____

Competitor Names: _____

_____

Theory

1. (2 pts) The point at which a Type Ia supernova explodes is known as _____.
   a) the Chandrasekhar limit
   b) the Roche limit
   c) the Eddington limit
   d) the Tolman–Oppenheimer–Volkoff limit

2. (2 pts) The main classification difference between Type I and Type II supernovae is _____.
   a) Type II supernovae occur frequently in elliptical galaxies
   b) Type II have light curves that exhibit sharp peaks at maxima
   c) Type I have hydrogen emission lines in their spectra
   d) Type II have hydrogen lines in their spectra

3. (2 pts) Type Ia supernovae were previously considered "standard candles" throughout the universe (and now considered "standardizable") because _____.
   a) they all explode at the same time so astronomers can determine their ages
   b) they all explode at the same point in their lifetime after passing the limit of 1.4 solar masses so they emit (approximately) the same level of brightness allowing astronomers to determine their distances
   c) they are most frequently present in irregular galaxies throughout the universe
   d) they are always located at the center of galaxies so astronomers can view those galaxies using supernovae light emissions when they explode

4. (2 pts) Energy released by a supernova explosion can reach up to _____ (or the equivalent of the total energy output by the sun over the course of its 10 billion year lifetime)!
   a) 10^{24} Joules
   b) 10^{30} Joules
   c) 10^{44} Joules
   d) 10^{56} Joules

5. (2 pts) Which of the following are possible progenitors for a Type Ia supernova?
   a) the binary model
   b) triple degenerate progenitors
   c) double degenerate progenitors
   d) Type Iax supernovae

6. (2 pts) Which is characteristic of Type Ia supernovae?
   a) Fe II and Ca II spectra lines
   b) light curve plateaus
   c) associated with gamma ray outbursts
   d) silicon absorption feature at maximum light spectra

7. (2 pts) The term "reddening" explains what phenomenon?
   a) redshifting of distant galaxies from the expansion of the universe
   b) the absorption of higher wavelength light by gas and dust that block distant galaxies from Earth's view
   c) the decreasing amount of red wavelengths observed emitting from distant Type Ia supernovae
   d) the process by which dust grains absorb and scatter shorter wavelength light more efficiently

8. (2 pts) At which stage of stellar evolution are the heaviest elements created?
   a) protostar
   b) main-sequence
   c) giant
   d) supernovae (Type Ia)

9. (4 pts) The majority of cataclysmic variable stars are also known as (2 pts) _____ and provide insight into the astrophysical process of (2 pts) _____.
   a) mergers; gravitational contraction
   b) mergers; accretion
   c) mass-transferring binary systems; accretion
   d) mass-transferring binary systems; thermonuclear expansion

10. (2 pts) Theoretically, if a white dwarf is unable to undergo a supernova explosion, it becomes a _____.
   a) black dwarf
   b) brown dwarf
   c) degenerate star
   d) neutron star

For questions 11 to 20, determine whether the statements are true or false.

11. (1 pt) At about 1.4 solar masses, a thermonuclear flame rips through a white dwarf, fusing carbon into heavier elements with a sudden release of energy that tears the star apart; this works in conjunction with gravity overcoming the force of electron degeneracy pressure to cause the explosion into a Type Ia supernova.

12. (1 pt) Supernovae explosions have no effect on neutrino measurements.

13. (1 pt) The Sun will become a neutron star at the end of its life.

14. (1 pt) Type Ia supernovae can outshine galaxies.

15. (1 pt) A brown dwarf initially has less than or equal to 1 solar mass.

16. (1 pt) SNR is an acronym representing SuperNova Remnant

17. (1 pt) A supernova explodes in a distant galaxy. The core of the surviving star has a mass of 5 solar masses. It will become a neutron star.

18. (1 pt) Neutron degeneracy is a stellar application of the Pauli Exclusion Principle and will not be able to stop the collapse of a core whose star's mass exceeds 3 solar masses.

19. (1 pt) As the mass of all stars increase, the luminosity of the star also increases rapidly.

20. (1 pt) All white dwarfs become progenitors of Type Ia supernovae.

21. (2 pts) After the red-giant branch, low-mass stars evolve into _____.
    a) the asymptotic giant branch
    b) the horizontal branch
    c) a white dwarf
    d) the main sequence

22. (2 pts) After becoming a white dwarf, this stellar remnant becomes _____.
    a) hotter and dimmer
    b) cooler and dimmer
    c) hotter and brighter
    d) cooler and brighter

23. (2 pts) Type Iax supernovae differ from Type Ia supernovae because _____.
    a) helium accretes onto the white dwarf and the progenitor is not always destroyed
    b) carbon accretes onto the white dwarf and the progenitor is not always destroyed
    c) the white dwarf merges with another white dwarf
    d) the white dwarf progenitor is always completely destroyed

24. (2 pts) The electron degeneracy pressure states that as the position of electrons becomes increasingly confined, _____.
    a) the electrons' momentum and therefore the sum of their pressures increases
    b) the electrons' combined mass and therefore the sum of their acceleration decreases
    c) the electrons' acceleration and therefore the sum of their combined force increases
    d) the electrons' combined force and therefore the sum of their charge decreases

25. (2 pts) Which of the following is not a type of SN remnant?
    a) shell
    b) nebula
    c) composite
    d) open

26. (2 pts) Which of the following is another name for a Type Ia supernova?
    a) pair-instability supernova
    b) core-collapse supernova
    c) thermonuclear runaway supernova
    d) gravitational contraction supernova

27. (2 pts) Which of the following is not used to measure distance?
    a) Cepheids
    b) RR Lyrae
    c) Type Ia supernovae
    d) T Tauri stars

28. (2 pts) When does a star become a main-sequence star?
    a) when the star exhausts its hydrogen and begins burning helium
    b) when the star undergoes a helium flash
    c) when the star starts generating energy through the triple-alpha process
    d) when it begins fusion of hydrogen into helium

29. (2 pts) A low-mass star is defined as having _____
    a) < 2 solar masses
    b) < 4 solar masses
    c) < 8 solar masses
    d) < 10 solar masses

30. (2 pts) Which of the following evolutionary phases do low-mass stars never undergo?
    a) planetary nebula phase
    b) white dwarf star
    c) supergiant branch star
    d) asymptotic giant branch star

For questions 31 through 49, fill in the blank on the answer sheet.

31. (2pts) Reflection nebulae mostly appear _____ while emission nebulae mostly appear _____. *Hint: the optical spectrum color*.

32. (2 pts) To determine the total mass in a binary star system, the two variables that must be observed are _____ and _____.

33. (2 pts) The two components of the coordinate system used to locate stars are _____ and _____, analogous to longitude and latitude respectively.

34. (1 pt) The "reflecting power" of an object in astronomy is referred to as _____.
Hint: the ratio of the radiation reflected from an object to the total amount incident upon the object.

35. (1 pt) According to Kepler's Laws, all orbits of the planets are _____.

36. (1 pt) The level of variation an object has from a perfectly circular orbit is called _____.

37. (1 pt) Most stars emit a majority of their radiant energy in the _____ wavelength.

38. (2 pts) White dwarfs have roughly ___ solar mass(es) and are roughly the size of the planet _____.

39. (2 pts) Protostars undergo the process _____ which is followed by the evolutionary stage of being a _____ star.

40. (1 pt) Reddening is dependent on _____, assuming dust in the interstellar medium increases that variable (in the blank) increases.

41. (1 pt) The mean distance of the earth from the sun in astronomical units is _____.

42. (1 pt) The process, _____, produces a star's energy.

43. (1 pt) _____ is an astronomical process that is analogous to the decreasing pitch of the siren from a truck that is moving away.

44. (1 pt) Besides the temperature, the luminosity of a star depends upon its property, _____.

45. (1 pt) _____ is the angular position of the sun at solar noon with respect to the plane of the equator.

46. (1 pt) The term "parsec," a unit of measurement for interstellar space, is a contraction of _____ _____.

47. (1 pt) A first magnitude star is ____ times brighter than a second magnitude star.

48. (1 pt) Brown dwarfs are classified as such because they are unable to perform the process _____.

49. (2 pts) A hot star has a(n) _____ color compared to a cooler ____ color star.

For questions 50 through 54, circle the answer on the answer sheet.

50. Type Ia supernovae do/do not leave a compact remnant.

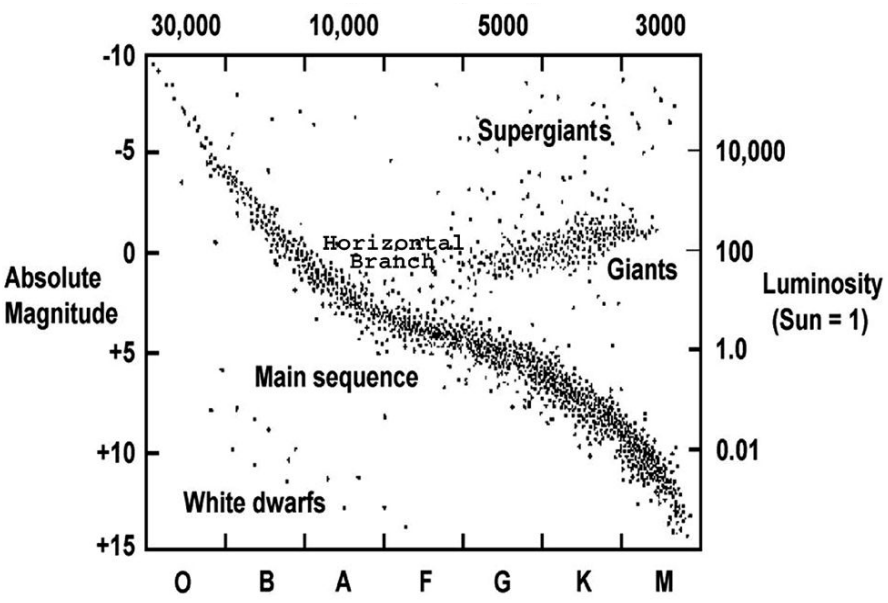
51. In Type Ia supernovae, radioactive ^{56} Nickel/Cobalt produce the optical lightcurve.

52. The white dwarf progenitors of Type Ia supernovae are typically formed from the elements carbon/nitrogen and hydrogen/oxygen.

53. Approximately 100 years of conduction/convection/radiation precede ignition of Type Ia supernovae.

54. The burning front of a Type Ia supernova can propagate through deflagration (which results in a supersonic/subsonic wave) or detonation (which results in a supersonic/subsonic wave).

Questions 55 through 59 refer to the following diagram.



55. What are the units across the top axis of the diagram?

56. What do the letters on the bottom axis of the diagram represent?

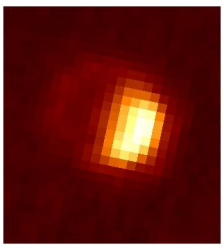
57. Where would the sun be located on this diagram? List the spectral class and absolute magnitude.

58. What is not shown on the diagram?
   a) the evolution of main-sequence stars
   b) stellar luminosity
   c) temperature of stars
   d) physical location of stars

59. Which spectral class is not applicable to supergiants?
   a) M
   b) K
   c) B
   d) Z

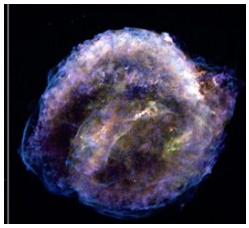
DSOs

60. (4 pts)



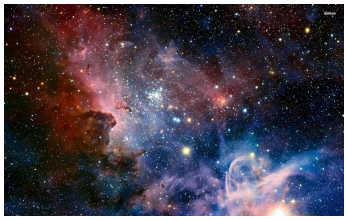
   a) Identify this DSO.
   b) Identify the galaxy this DSO is located in.
   c) When and where would the event causing this DSO have been visible on Earth?
   d) What is the most likely progenitor of this SNR?

61. (4 pts)



a) Identify this DSO.
b) In which year was this DSO (or the event that caused this DSO) first sighted?
c) Which famous astronomer was this DSO named after?
d) Which type of SNR is this DSO?

62. (4 pts)

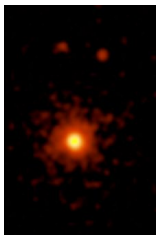


a) Identify this DSO.
b) Who discovered this DSO?
c) What is the apparent magnitude of this DSO?
d) Who discovered the dark cloud within this DSO that contains globules and fluorescent gas?

63. (4 pts)

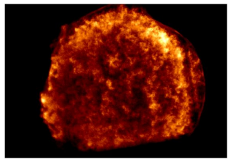
a) Identify the DSO which is notable for being the first observed outside the Milky Way Galaxy.
b) When was this DSO observed?
c) Identify the constellation this DSO is located in.
d) What is unique about the coloration of this DSO and why is this controversial for its classification?

64. (4 pts)



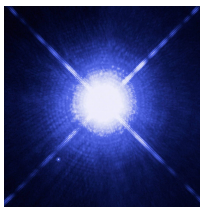
a) Identify this DSO.
b) What wavelength was this image taken in?
c) Which evolutionary stage will this DSO reach at the end of its life?
d) How far is this DSO from Earth in lightyears?

65. (4 pts)



a) Identify this DSO.
b) What wavelength was this image taken in?
c) How far is this DSO from Earth in lightyears?
d) List two other designations for this DSO.

66. (4 pts)



a) Identify this DSO. *Note: the DSO refers to the source of the emission visible in the image*.

b) What is its spectral type?

c) What is the mass of its companion in solar masses?

d) What is the range of separation in AU?

67. (4 pts)

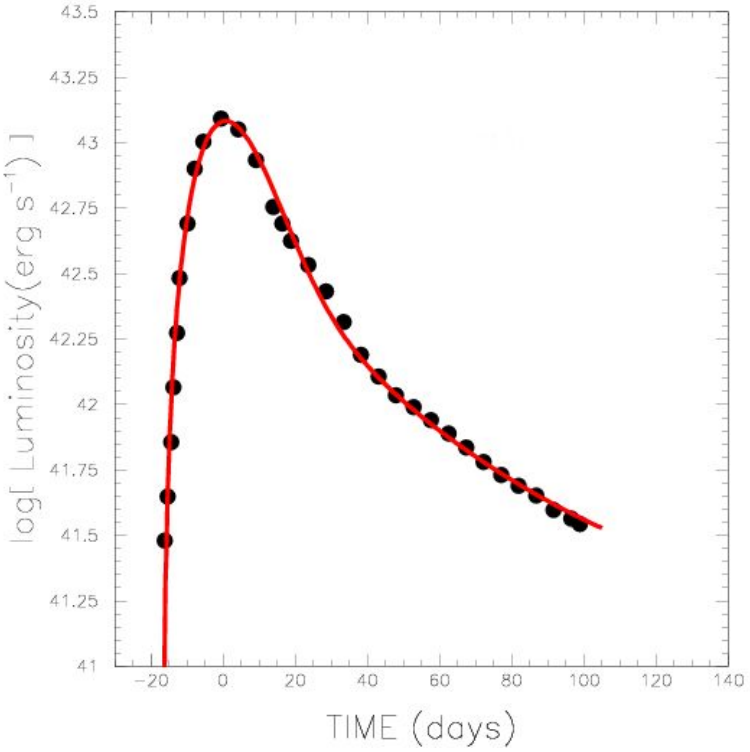
a) Identify this DSO.

b) Which nearby physical object varies brightness due to being illuminated by this DSO?

c) This type of DSO are powered by what process?

d) What is the mass range for this type of DSO?

68. (4 pts)



a) Identify the DSO that exhibited this light curve.

b) What widely accepted idea was verified by the cause of this DSO?

c) What was its peak apparent magnitude?

d) Which galaxy was this DSO located in?

69. (1 pt) The brightest star in the visible sky is _____.

70. (1 pt) The star closest to our sun is _____.

Math

Give all answers using significant figures. Show work for partial credit.

71. (4 pts) Given that Type Ia supernova BrightBurst exploded with an apparent magnitude of +14.8, calculate the distance to the remnants. Give your answer in lightyears.

72. (2 pts) Star A has a brightness of 2.0μW/m^2 and is 4.0 ly away. Star B has a brightness of 4.0μW/m^2 and is 18.0 ly away. How much more luminous is Star B than Star A?

73. (4 pts) A binary star system is composed of one star that is 2 times as massive as the other. It has an orbital period of 250 y and the two stars are 80.0 AU apart. What is the mass of the smaller star? Give your answer in solar masses.

74. (4 pts) In a binary system, a star of of mass 1.796×10^{30} kg is orbiting a star of mass 1.437×10^{29} kg. The force exerted on it is $5.482*10^{24}$ N. Determine the separation. Give your answer in AU.

75. (3 pts) Given that the peak wavelength of a star's blackbody radiation curve is 483 nm, determine its effective temperature. Give your answer in Kelvin.

Bonus question (0 pts) [Joke!]: Where is the center of gravity? _____