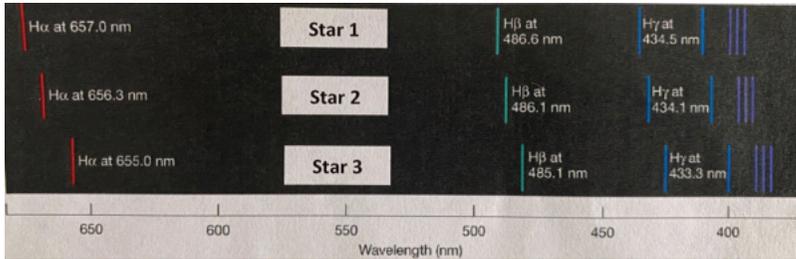


B - Reach for the Stars - Nov 7 Country-wide SO Practice - 11-07-2020

Welcome! Please read all instructions carefully and submit your answers accordingly.

Questions 1-5 are related to Image 1, which shows the spectral characteristics of three stars of similar composition.



1. (1.00 pts) Which element's spectral characteristics are displayed in Image 1?

- A) Hydrogen
- B) Helium
- C) Sodium
- D) Iron
- E) None of the above

2. (1.00 pts) Image 1 shows the absorption spectrum characteristics of the three stars.

- True
- False

3. (1.00 pts) To a distant observer, Star 2 (center) is at rest. Then Star _____ is moving away from the observer.

1

4. (2.00 pts) Which properties of these stars can be inferred from the image?

(Mark ALL correct answers)

- A) Mass
- B) Red (or blue) shift
- C) Radioactivity
- D) Luminosity
- E) Relative velocity

5. (2.00 pts) What is the relative speed of star 3 as noticed by the observer?

Expected Answer: Star 3 is moving towards the observer at a speed of 600km/s. Allow some variation in exact value (e.g. 580-620 km/s or any other unit of speed) Expect steps: 1. Doppler shift formula: $v/c = (\text{Star 2 Ha} - \text{Star 3 Ha})/\text{Star 2 Ha}$. 2. Can use any other spectral line Hb/Hg

6. (1.00 pts) What is the general relationship between the mass of a star and its lifespan?

Expected Answer: The mass of a star is inversely related to its expected lifespan.

7. (2.00 pts) Explain your reasoning for the previous answer.

Expected Answer: Massive stars undergo more intense fusion at their cores and burn through their fuel much faster than less massive stars.

8. (2.00 pts)

White dwarfs can go supernova when they approach a mass of _____ solar mass. The technical name of this "critical mass" is _____.

1.4

Chandrasekhar limit

9. (1.00 pts) Brown dwarfs do not have enough mass to start nuclear fusion.

True False

10. (1.00 pts) When a white dwarf gains too much mass and explodes, it results in a Type ____ supernova.

1a

11. (2.00 pts) Which of these items can be a Type II supernova remnant?

(Mark ALL correct answers)

- A) Neutron star
- B) Red giant star
- C) Black hole
- D) Pulsar
- E) None of the above

12. (2.00 pts)

Altair and _____ are two stars (in this year's list) that are flattened at the poles and bulging at the equator. This feature is primarily due to the stars' _____ and non-solid composition.

Vega

rapid rotation

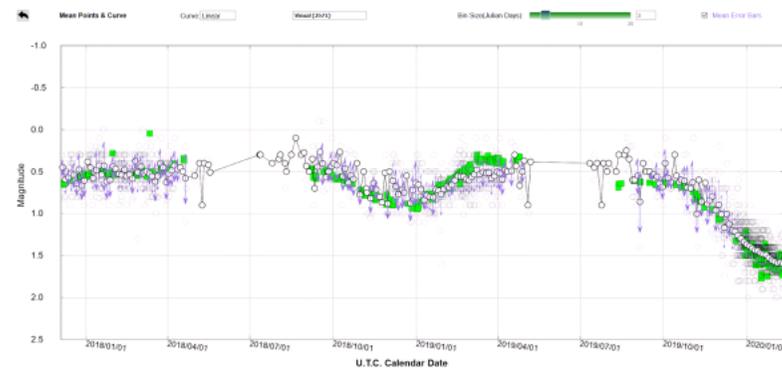
13. (2.00 pts) What are the main differences (state at least two) between Population I and Population II stars?

Expected Answer: 1. Age (Pop I stars are younger) 2. Metallicity (Pop I stars are metal-rich) 3. Composition (Pop II stars have more H/He)

14. (4.00 pts) Explain how stars of the two population types may have formed and evolved.

Expected Answer: The older Pop II stars formed when the Universe was younger and was composed mainly of H and He gases. After these stars had fused H and He into heavier elements, they often scattered material back into space (through supernovae and planetary nebula). Younger Pop I stars then formed out of gaseous clouds of H, He and the metal-rich remains of Pop II stars.

Questions 15-18 are related to Image 2.



15. (1.00 pts) The image represents the _____ of Alpha Orionis, a star in the Orion constellation.

- A) Constellation chart
- B) Emission spectrum
- C) Light curve
- D) Thermal image
- E) None of the above

16. (1.00 pts) It can be inferred that the star was growing brighter in early 2020.

- True
- False

17. (1.00 pts) The star in question is popularly known as

- A) Bellatrix
- B) Betelgeuse
- C) Mintaka
- D) Rigel
- E) None of the above

18. (1.00 pts) This star is typically the brightest in Orion constellation.

- True
- False

Questions 19-22 are related to the following two images.

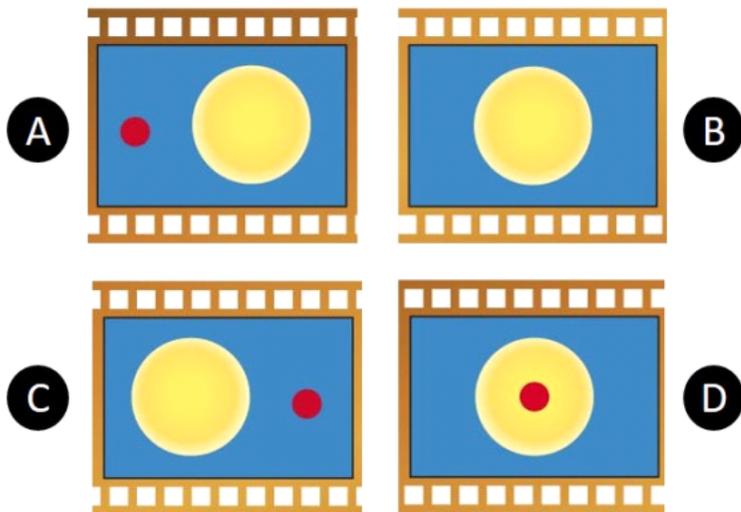


Image 3 shows the different phases of an eclipsing binary star system.

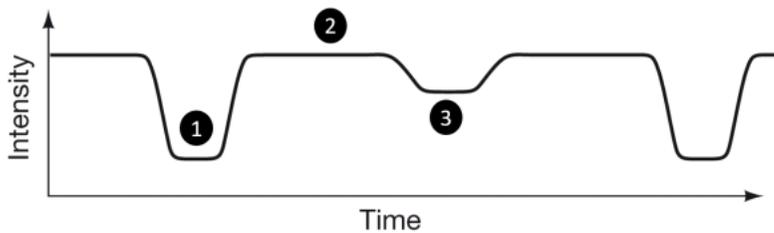


Image 4 shows the light curve of the same star system.

19. (1.00 pts) Which phase in Image 3 is described by label 1 in Image 4?

- A) Phase A
- B) Phase B
- C) Phase C
- D) Phase D
- E) Cannot tell from the given information

20. (1.00 pts) Which phase in Image 3 is described by label 2 in Image 4?

- A) Phase A
- B) Phase B
- C) Phase C
- D) Phase D
- E) Cannot tell from the given information

21. (1.00 pts) Which phase in Image 3 is described by label 3 in Image 4?

- A) Phase A
- B) Phase B
- C) Phase C
- D) Phase D
- E) Cannot tell from the given information

22. (2.00 pts) What additional information can resolve any doubts you may have in answering any of the previous three questions?

- A) Luminosity of the stars
- B) Distance between the stars
- C) Direction of orbital rotation
- D) Orbital periodicity
- E) None of the above

Questions 23-30 refer to Image 5 below.

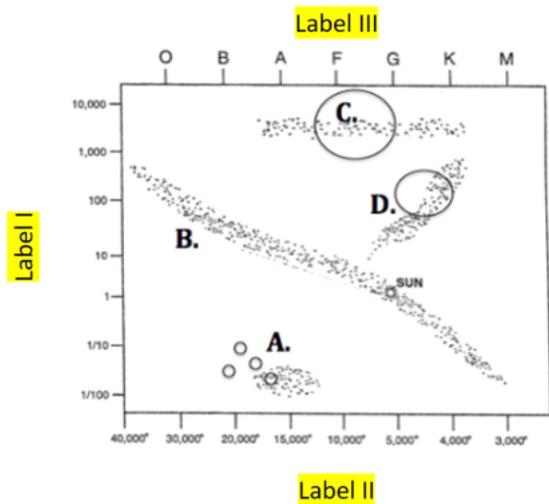


Image 5: H-R diagram showing location of four stars labeled A-D.

23. (1.00 pts) What property does Label I represent?

- A) Absolute magnitude
- B) Luminosity
- C) Spectral Class

- D) Temperature
- E) None of the above

24. (1.00 pts) What property does Label III represent?

- A) Absolute magnitude
- B) Luminosity
- C) Spectral class
- D) Temperature
- E) None of the above

25. (1.00 pts) Which of the stars is oldest in terms of the life cycle?

- A) Star A
- B) Star B
- C) Star C
- D) Star D
- E) None of the above

26. (1.00 pts) Which of the stars is burning Hydrogen as fuel?

- A) Star A
- B) Star B
- C) Star C
- D) Star D
- E) Cannot tell from the given information

27. (2.00 pts) Which of the stars are burning Helium as fuel?

(Mark **ALL** correct answers)

- A) Star A
- B) Star B
- C) Star C
- D) Star D
- E) Cannot tell from the given information

28. (1.00 pts) Which of the stars is the brightest?

- A) Star A
- B) Star B
- C) Star C
- D) Star D
- E) Cannot tell from the given information

29. (1.00 pts) The star that is brightest has the highest surface temperature.

- True False

30. (1.00 pts) In a future time, Star C will move to the stage currently occupied by which star?

- A) Star A
 B) Star B
 C) Star D
 D) None of the above

Questions 31-40 are related to Image 6.

Time: 2020-11-07 06:00:00 UT, whole sky

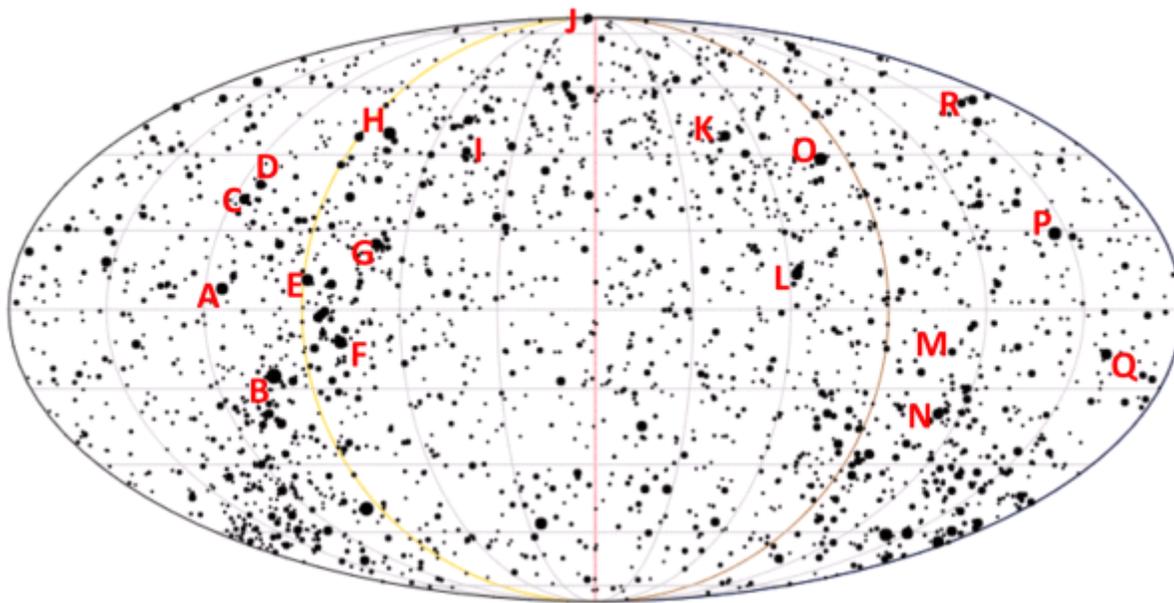


Image 6: The labels A-R

correspond to stars from this year's list.

31. (1.00 pts) Which letter represents the star Antares?

- A) L
 B) M
 C) N
 D) Q
 E) None of the above

32. (1.00 pts) Which star is labeled by the letter G?

- A) Algol
 B) Pollux

- C) Procyon
- D) Aldebaran
- E) None of the above

33. (3.00 pts) Which letters represent the stars of the Summer Triangle asterism?

(Mark ALL correct answers)

- A) K
- B) L
- C) M
- D) N
- E) O

34. (3.00 pts) Which letters represent the stars of the Winter Triangle asterism?

(Mark ALL correct answers)

- A) A
- B) B
- C) C
- D) D
- E) E

35. (1.00 pts) The letter J represents the star _____.

Polaris

36. (1.00 pts) Which letter corresponds to the brightest star in the night sky?

- A) A
- B) B
- C) F
- D) O
- E) P

37. (1.00 pts) Assuming you are located in the continental United States, you'll be able to see ALL the stars labeled A-R if you stepped out tonight and looked up at the night sky.

- True
- False

38. (2.00 pts) From the list of label pairs, select ALL the pairs that correspond to stars belonging to the same constellation.
NOTE: different pairs of labels correspond to different constellations.

(Mark ALL correct answers)

- A) A and B
- B) C and D
- C) E and F

- D) E and G
- E) M and N

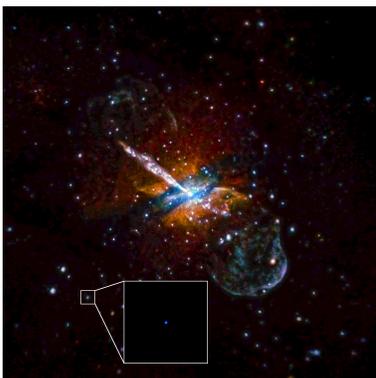
39. (1.00 pts) Which label corresponds to a PAIR OF STARS that cannot be distinguished by naked eye?

- A) L
- B) P
- C) Q
- D) R
- E) None of the above

40. (1.00 pts) The star with label _____ does not change its position significantly in the night sky.

- A) A
- B) D
- C) J
- D) P
- E) None of the above

Questions 41-44 correspond to Image 7 below.



41. (1.00 pts) Which DSO is shown in the image above?

- A) Andromeda galaxy
- B) Centaurus A
- C) Baby boom galaxy
- D) 30 Doradus
- E) None of the above

42. (2.00 pts) The central part of the image depicts a _____ galaxy formed by the collision of a larger elliptical galaxy with a smaller _____ galaxy.

starburst

spiral

43. (1.00 pts) What type of electromagnetic radiation is captured in the inset image?

- A) Infrared
- B) Visible
- C) Ultraviolet
- D) X-ray
- E) None of the above

44. (1.00 pts) The flares shown in the inset appear to come from intense radiation from ultra-luminous sources.

- True
- False

Questions 45-47 are related to Image 8 below.

45. (1.00 pts) Which DSO is shown in the image above?

- A) Andromeda galaxy
- B) Antennae galaxy
- C) Baby boom galaxy
- D) GNz-11
- E) None of the above

46. (2.00 pts) The surface brightness shown in the left panel of the image above is likely due to:

(Mark ALL correct answers)

- A) Galactic interaction
- B) Massive star formation
- C) Supernova remnant
- D) Merger of black holes
- E) None of the above

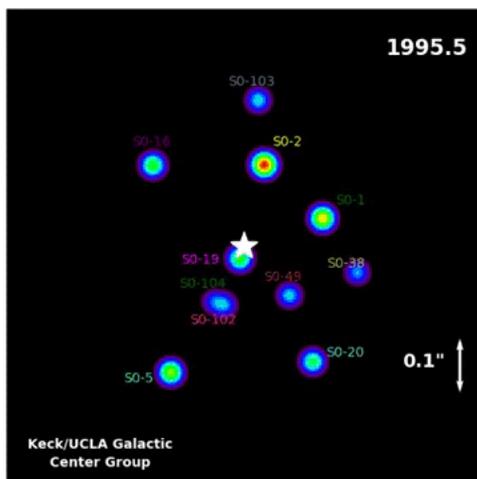
47. (2.00 pts) The right panel shows a map of expansion velocity of the bubbles (indicated by the different circles). What features of the bubbles might be captured in this image?

(Mark ALL correct answers)

- A) Supermassive black holes are consuming energy from the stars

- B) Stellar winds emanating from active star clusters
- C) Supernova explosions in the star clusters
- D) Flares emitted from pulsars
- E) None of the above

Questions 48-50 are related to Image 9 below.



48. (1.00 pts) Which DSO is shown in the image above?

- A) Centaurus A
- B) T Tauri
- C) Sagittarius A*
- D) DLA0817g
- E) None of the above

49. (1.00 pts) Which galaxy does the DSO belong to?

- A) Baby boom galaxy
- B) GNz-11
- C) Milky Way galaxy
- D) Andromeda galaxy
- E) None of the above

50. (2.00 pts) What information is inferred from the evidence in the animated image above?

Expected Answer: Images taken from many years are used to track specific stars orbiting the proposed black hole. These orbits, and a simple application of Kepler's Laws, provide the best evidence yet for a supermassive black hole at the center of the Milky Way galaxy.

Questions 51-72 are related to the Image Set below.



51. (2.00 pts) Which two images show one of the best nearby examples of a collision between two spiral galaxies?

(Mark ALL correct answers)

- A) Image D
- B) Image F
- C) Image L
- D) Image M
- E) Image Q

52. (1.00 pts) Which DSO is shown in the image labeled A?

- A) 30 Doradus
- B) GN-z11
- C) Sgr A*
- D) DLA0817g
- E) None of the above

53. (1.00 pts) The image labeled A shows the most distant rotating disk galaxy ever observed.

- True
- False

54. (1.00 pts) Which DSO is shown in Image B?

- A) Andromeda galaxy
- B) Pinwheel galaxy
- C) NGC 4555
- D) NGC 6334
- E) None of the above

55. (2.00 pts) What X-ray sources are visible in the inset shown in Image B?

(Mark ALL correct answers)

- A) T Tauri protostars
- B) Neutron stars
- C) Supermassive black hole
- D) Magnetars
- E) None of the above

56. (3.00 pts)

Image C from NASA's Spitzer Space Telescope was taken in the _____ spectrum. It shows the _____ nebula. This turbulent region, jam-packed with stars, is home to some of the most luminous massive stars in our Milky Way galaxy. It is located approximately 30,000 light-years away in the _____ constellation.

Infrared

Dragonfish

Crux

57. (3.00 pts) Which DSO is shown in Image D?

- A) Cat's Paw Nebula
- B) Bear's Claw Nebula
- C) Tarantula Nebula
- D) Dragonfish Nebula
- E) Lagoon Nebula

58. (1.00 pts) The inset in Image E shows the farthest galaxy ever seen.

- True
- False

59. (1.00 pts) The DSO in Image E is:

- A) GNz-11
- B) Sgr A*
- C) 30 Doradus
- D) M104
- E) None of the above

60. (1.00 pts) The DSO shown in Image G is:

- A) M42
- B) M60
- C) M101
- D) M104
- E) None of the above

61. (1.00 pts) The inset in image G shows the densest galaxy ever to be found.

- True
- False

62. (1.00 pts) Image I shows a capture in _____ part of EM spectrum.

- A) Microwave
- B) Infrared
- C) Visible
- D) Ultraviolet
- E) X-ray

63. (2.00 pts) Which DSO is shown in Image K?

(Mark ALL correct answers)

- A) Baby Boom galaxy
- B) Sombrero galaxy
- C) M101
- D) M104
- E) Andromeda galaxy

64. (1.00 pts) Which image shows the Cat's Paw nebula?

- A) Image D
- B) Image H
- C) Image J
- D) Image L
- E) Image O

65. (1.00 pts) The Cat's Paw is an emission nebula with a red color that originates from an abundance of ionized hydrogen atoms.

- True
- False

66. (2.00 pts)

Image P, taken at ESO's Paranal Observatory in Chile, shows the four Auxiliary Telescopes of the Very Large Telescope (VLT) Array. Which **constellations** are visible in the sky?

(Mark ALL correct answers)

- A) Doradus
- B) Canis Major
- C) Taurus
- D) Tucana
- E) Ursa Minor

67. (1.00 pts) Image N: This ethereal NASA illustration from 2013 shows a close-up of cosmic clouds and stellar winds in the _____ Nebula.

Orion

68. (1.00 pts) The colorful clouds in Image L compose one of the closest star forming regions in _____.

- A) Orion nebula
- B) Rho Ophiuchi cloud complex
- C) Lagoon nebula
- D) 30 Doradus
- E) None of the above

69. (2.00 pts)

Image Q: Chandra's image of NGC 4555 revealed that it is embedded in a cloud of 10-million-degree Celsius gas (left). This hot gas cloud has a diameter of about 400,000 light years, roughly twice that of the visible galaxy (right). What is the possible cause for holding the disproportionately large gas cloud to the galaxy?

Expected Answer: An enormous envelope, or halo, of dark matter is needed to hold the hot gas cloud to the galaxy. The total mass of the required dark matter halo is about ten times the combined mass of the stars in the galaxy, and 300 times the mass of the hot gas cloud.

70. (1.00 pts) Which DSO is shown in Image J?

- A) Baby Boom galaxy
- B) The Mice galaxies
- C) Milky Way galaxy
- D) Andromeda galaxy
- E) None of the above

71. (1.00 pts) Image J: The green and red splotch in this image is the most active star-making galaxy in the very distant universe.

- True
- False

72. (2.00 pts) What kind of activity might be responsible for the activity shown in Image J?

Expected Answer: Baby Boom is a type of galaxy called a starburst. Like some other starbursts, it is thought to be a collection of colliding galaxies. As the galaxies smash together, gas becomes compressed, triggering the birth of stars.

73. (4.00 pts)

A star radiates most strongly at the wavelength of 200nm. Its surface temperature is _____ degrees Kelvin, and it belongs to _____ [O/A/B/K] spectral class.
NOTE: Use $b = 2.9 * 10^{-3} mK$.

14500

B

74. (2.00 pts) A star with the same color as the Sun produces a luminosity that is 81 times larger. What is its radius compared to Sun's radius (R_{\odot})?

- A) R_{\odot}
- B) $3R_{\odot}$
- C) $R_{\odot}/3$
- D) $9R_{\odot}$
- E) $R_{\odot}/9$

75. (2.00 pts) If one observes a nearby galaxy at a distance of 1 Mpc ($= 10^6$ parsecs), what is the apparent magnitude of Sun-like stars in that galaxy?
NOTE: Absolute magnitude of Sun is 4.8

- A) -4.8
- B) 9.6
- C) 19.8
- D) 29.8
- E) Cannot tell from the given information

76. (4.00 pts) State at least two shortcomings of Hubble's classification scheme of galaxies.

Expected Answer: 1. A common criticism of the Hubble scheme is that the criteria for assigning galaxies to classes are subjective, leading to different observers assigning galaxies to different classes. 2. Another criticism of the Hubble classification scheme is that, being based on the appearance of a galaxy in a two-dimensional image, the classes are only indirectly related to the true physical properties of galaxies. In particular, problems arise because of orientation effects. The same galaxy would look very different, if viewed edge-on, as opposed to a face-on or 'broadside' viewpoint. As such, the early-type sequence is poorly represented: the ES galaxies are missing from the Hubble sequence, and the E5–E7 galaxies are actually S0 galaxies. Furthermore, the barred ES and barred S0 galaxies are also absent. 3. Visual classifications are also less reliable for faint or distant galaxies, and the appearance of galaxies can change depending on the wavelength of light in which they are observed.

77. (5.00 pts) Explain briefly the important evolutionary stages that are expected to happen to the Sun (and our Solar System) in the future.

Expected Answer: 1. In about 5 billion years Sun will have exhausted all the hydrogen at its core. The core will then shrink and nuclear reactions will take place in a large shell outside the core. The outer regions of the Sun will greatly expand and become a red giant. 2. The Sun will remain as a red giant, converting hydrogen to helium in an expanding shell around its core for about 1 billion years. The core will gradually get hotter and more dense due to the weight of helium. 3. When all of the helium in the core has been converted into carbon, nuclear reactions in the core will stop. The Sun will become more and more unstable. Eventually the whole of the outer regions of the Sun will be blown away forming a

glowing shell of plasma called a planetary nebula. 4. At the center of the planetary nebula the remnant of the Sun's core will collapse into an extremely dense hot star called a white dwarf. The remaining 70% of the Sun's mass will have been lost into space as stellar wind.

All done! Congratulations on finishing the test.