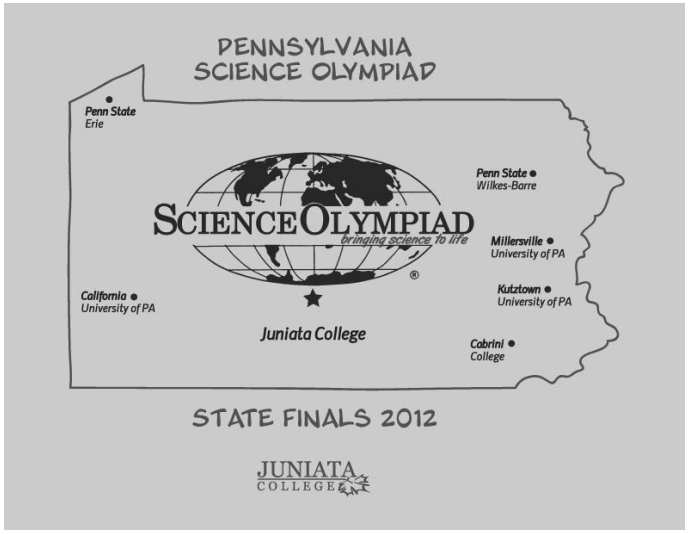


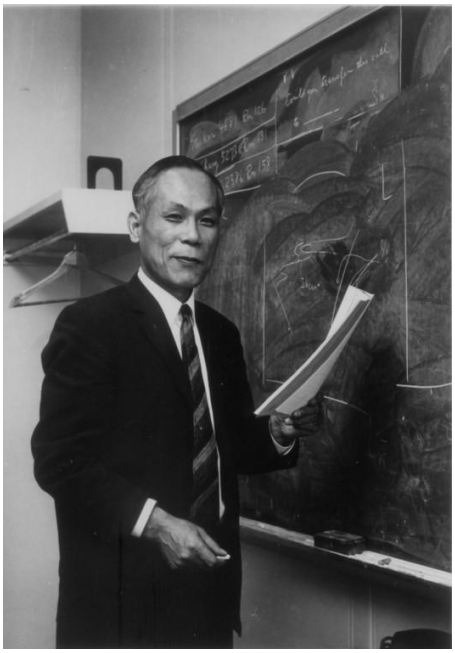
JUNIATA COLLEGE

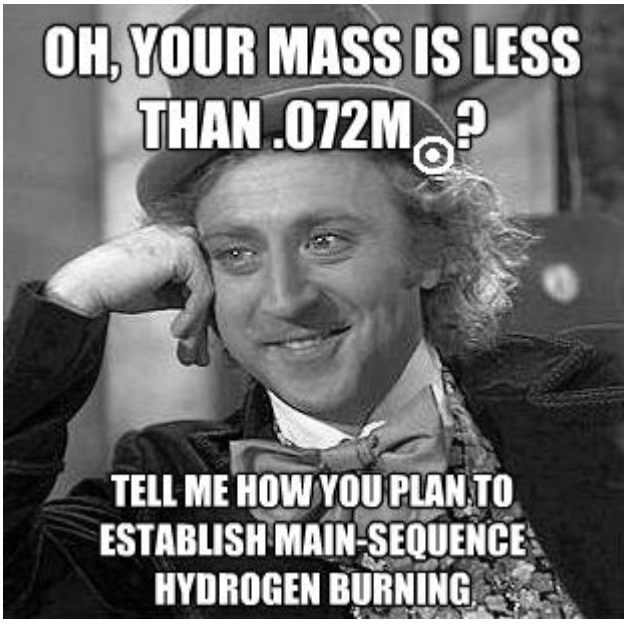
PENNSYLVANIA SCIENCE OLYMPIAD

STATE FINALS 2012

ASTRONOMY C DIVISION EXAM

APRIL 27, 2012





TEAM NUMBER _____ SCHOOL NAME_____

INSTRUCTIONS:

1. **Turn in all exam materials at the end of this event. *Missing exam materials will result in immediate disqualification of the team in question*. There is an exam packet as well as a blank answer sheet.**

2. **You may separate the exam pages. Submit the answer sheet separately.**

3. ***Only* the answers provided on the answer page will be considered. Do not write outside the designated spaces for each answer. You may write in the exam booklet.**

4. **Include school name and school team number at the bottom of the answer sheet as well as on the title page. Indicate the names of the participants *legibly* at the bottom of the answer sheet. Be prepared to display your wristband to the supervisor when asked. *If you do not have a wristband, you may not participate.***

5. **Each question is worth one point. Tiebreaker questions are indicated with a (T#) in which the number indicates the *order of consultation* in the event of a tie. Tiebreaker questions count toward the overall raw score, and are only used as tiebreakers when there is a tie. In such cases, (T1) will be examined first, then (T2), and so on until the tie is broken. There are 12 tiebreakers.**

6. **Pay close attention to the units given in the problem and the units asked for in the answer.**

7. **When the time is up, *the time is up*. Continuing to write after the time is up risks immediate disqualification.**

8. **Nonsensical, mocking, or inappropriate answers WILL RESULT IN DISQUALIFICATION.**

9. **In the bonus box on your answer sheet, indicate the name of the gentleman shown in the image on the *lower left side* of the cover sheet. Condescending Willy Wonka will not earn you the bonus.**

Questions numbered 1-35 refer to image page 1, image page 2, and the object list as published in section 3c of the Astronomy rules in the 2012 Science Olympiad Student Manual.

1. Which object is shown in image 11?

2. (T11) What is the name for the dark clouds in image 11?

3. This object contains a well-known LBV star of over 100 solar masses. What is this star called?

4. Consider image 18. This is an artist's conception of which object?

5. Which other image on image page 1 also shows the object in image 18?

6. Which image shows RX J0806.3+1527?

7. (T3) Which image shows an object that *most likely* looked like RX J0806.3+1527 prior to 400 years ago?

8. What is the name or designation of the object referred to in #7?

9. Which image shows an HII region located in the constellation Monoceros?

10. The object referred to in #9 contains an open cluster. What is the cluster's New General Catalogue number?

11. Which image shows an artist's conception of a recurrent nova?

12. Which object from the list is of the recurrent nova type?

13. In what month and year did the object in #12 last demonstrate an outburst?

14. Which image from image page 2 indicates the light curve from a recurrent nova?

15. (T10) Consider image 5. What is the Bayer designation of this object?

16. Which image from image page 2 indicates the light curve for the object in image 5?

17. When is the next predicted maximum for the object in image 5?

Several of the images on image page 1 indicate supernova remnants.

18. How many different supernova remnants are pictured on image page 1?

19. Which light curve image on image page 2 is associated with supernova remnants of this type?

20. Which spectrum image on image page 2 is associated with supernova remnants of this type?

21. Which image on image page 1 indicates a supernova that was visible in 1572?

22. Two images indicate supernova remnants from relatively young progenitor stars. List one.

23. (T4) The designations for these two objects include letters. What do the letters indicate?

24. Which one of the images indicates the last unquestioned supernova observed in the Milky Way?

25. Consider image 16. This is an artist's conception of what type of object?

26. Which image on image page 1 shows the prototype for this type of object?

27. A reflection nebula is associated with the object in #26. What is its popular name?

28. Which image on image page 2 indicates the light curve for the object in #26?

29. Which image on image page 1 features a planetary nebula?

30. In what constellation is this planetary nebula located?

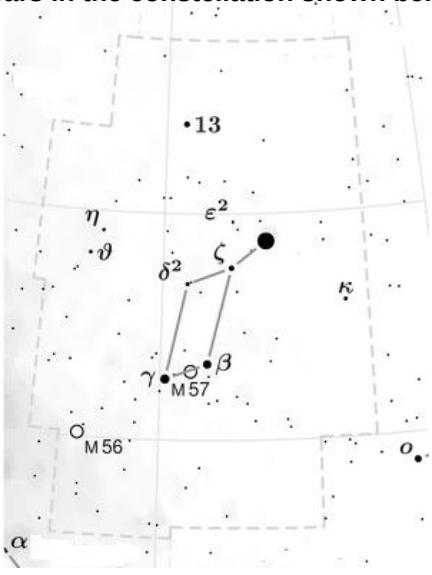
31. How many images on image page 1 contain (at least) one white dwarf in a multiple-star system?

32. Which image on image page 1 shows NGC 7078?

33. What is NGC7078's number in Bode's "Complete Catalog of hitherto unobserved Nebulous Stars and Star Clusters"?

34. What is the Shapley-Sawyer Concentration Class for NGC7078?

35. Which object from the object list appears in the constellation shown below?



36. Approximately how much energy is released in a Type Ia supernova explosion?

A) 10^{11} J B) 10^{22} J C) 10^{33} J D) 10^{44} J

37. During a Type Ia supernova explosion, which of the following is TRUE?

A) carbon fusion begins before oxygen fusion

B) helium fusion begins before hydrogen fusion

C) magnesium fusion begins before oxygen fusion

D) iron fusion begins before neon fusion

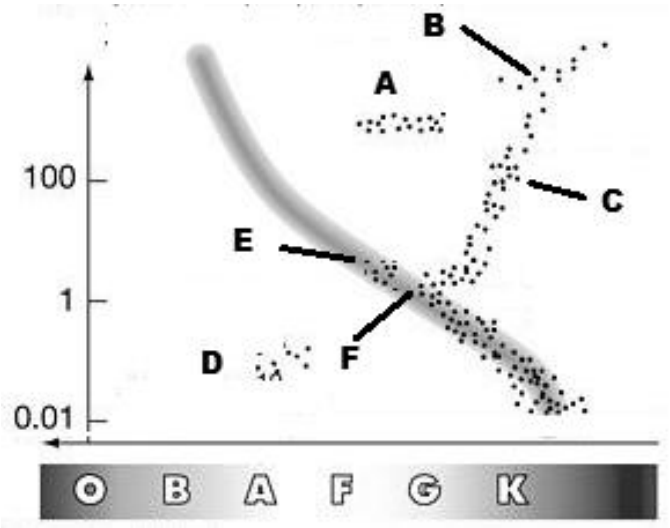
38. How old is the sun?

39. How old will the sun be when it leaves the main sequence?

40. (T9) Stars range from 0.08 solar mass to 100 solar masses. Why are there no stars with less than 0.08 solar mass?

41. Why are there no stars with more than 100 solar masses?

Consider the image shown below. This shows an HR diagram for a globular cluster. Use this diagram for numbers 42 – 48.



42. What is indicated by location A?

43. What is indicated by location B?

44. What is indicated by location C?

45. What are the objects indicated by the dots at location D?

46. What are the objects indicated by the dots at location E?

47. What is indicated by location F?

48. The stars at location F are 4 solar masses. What is the age of this globular cluster?

49. What is the term for a binary system composed of two white dwarfs that merge into a single mass that exceeds the Chandrasekhar limit and explodes in a Type Ia supernova?

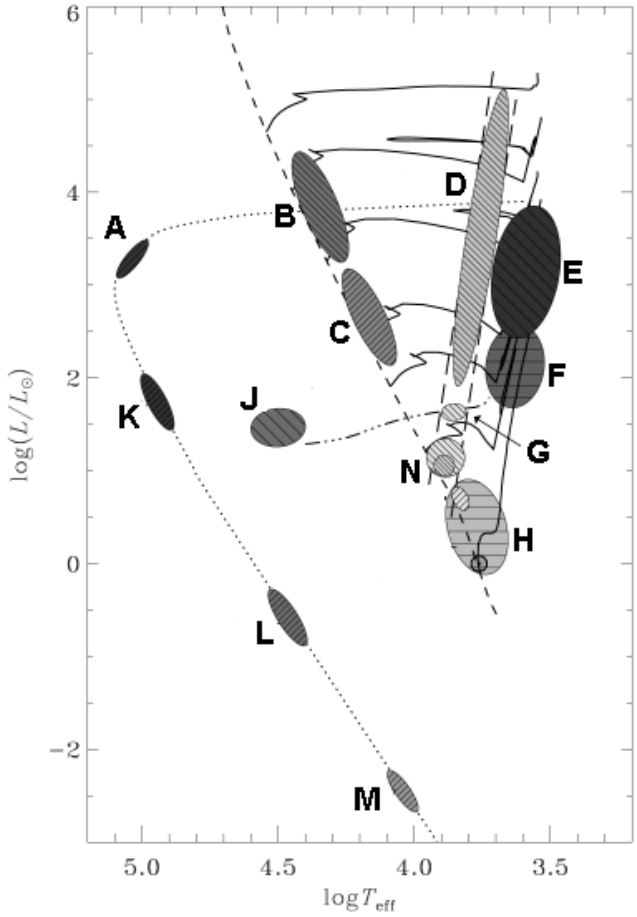
50. (T5) Emission lines from what element(s) dominate the *latter stages* of a Type Ia supernova light curve?

51. What is the absolute magnitude of a Type Ia supernova at its peak brightness?

52. How many times brighter than the sun is a Type Ia supernova at its peak brightness?

53. What astronomers pioneered the classification of supernovae, such that their criteria are still used today?

Consider the HR diagram shown below. Each lettered region represents a particular class of variable star. Use this diagram for questions numbered 54 – 59.



54. In which lettered region would we find DAV pulsating white dwarf stars?

55. In which lettered region would we find RR Lyrae stars?

56. In which lettered region would we find pulsating Mira variables?

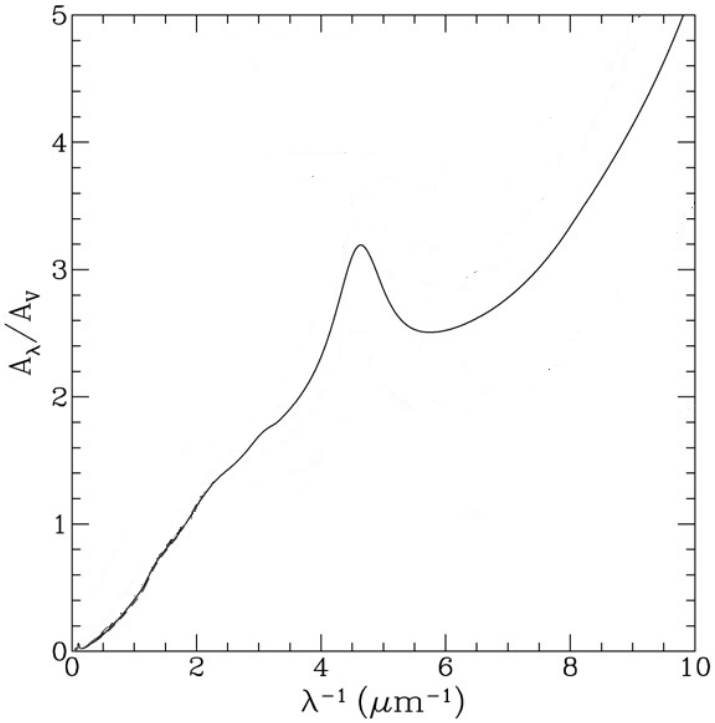
57. In which lettered region would we find PNNV variables?

58. What is indicated by the dashed line that contains lettered regions B, C, N, and H?

59. What is indicated by the pair of dashed lines that contain lettered regions D, G, and N?

60. What is the term for the obscuration of starlight due to the effects of scattering and absorption?

Consider the graph shown below. It describes the wavelength dependence of the phenomenon described in #60. Use this graph for numbers 61 and 62.



61. (T12) At what wavelength (in nm) does the "bump" appear?

62. What component of the ISM causes this bump?

63. Star-forming molecular clouds typically separate into discrete clumps during gravitational collapse. What is the term for this process?

64. As a collection of gas begins the process of gravitational collapse, that collapse is opposed by radiation pressure. What is the term for the minimum mass that can overcome the radiation pressure for a given energy density of radiation?

65. (T6) What is the name of the path on the HR diagram taken by protostars on their way to the Main Sequence?

66. Emission lines from a particular element are present in the spectrum of T-Tauri stars. This element implies stellar youth, as it is typically destroyed in the depths of older stars within a few million years. What is this element?

67. What does a CTTS star have that a WTTS does not have?

68. What feature of the emission lines from a T-Tauri star indicates mass outflow?

69. Once a star reaches the Main Sequence, which stellar characteristic determines how long it stays there?

70. The conversion of gravitational potential energy into radiation was once thought to be the origin of stellar luminosity. In such a case, what is the term for the length of time it would take to radiate away *all* of the star's gravitational potential energy at its current luminosity?

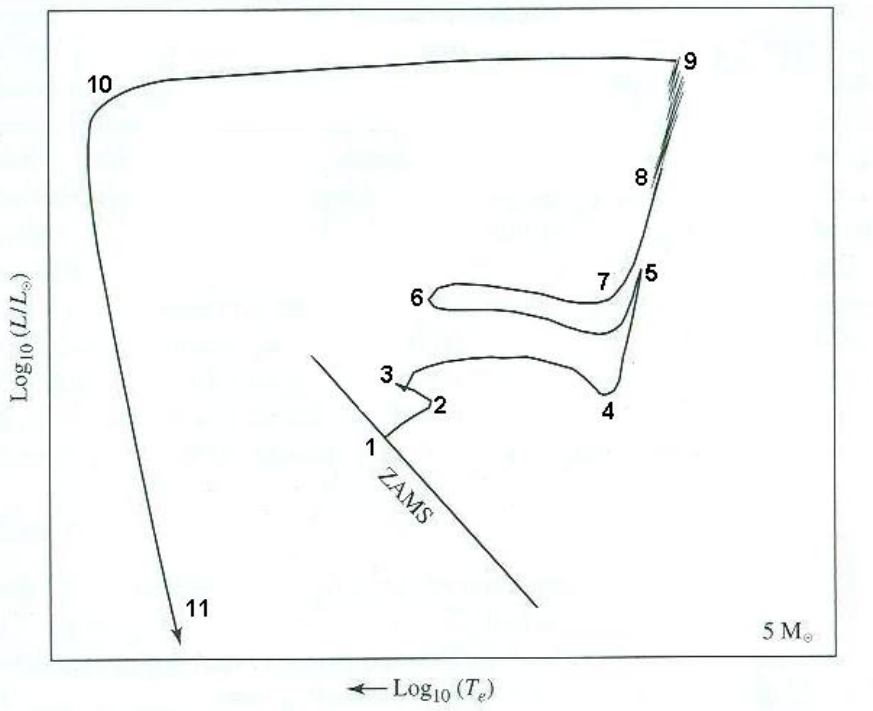
71. (T7) What is meant by the acronym ZAMS?

72. What element is most commonly used as a "tracer" to determine the presence of molecular hydrogen?

73. A star has a B magnitude of 9.69 and a visual magnitude of 9.97. What is this star's B-V color index?

74. What would you expect this star's spectral class to be?

Consider the image shown below. This shows post main sequence evolution of a 5-solar-mass star. Use this diagram for questions numbered 75 – 80.



75. Between which 2 numbers on the graph is the RGB?

76. Between which 2 numbers on the graph is the thermal-pulse AGB?

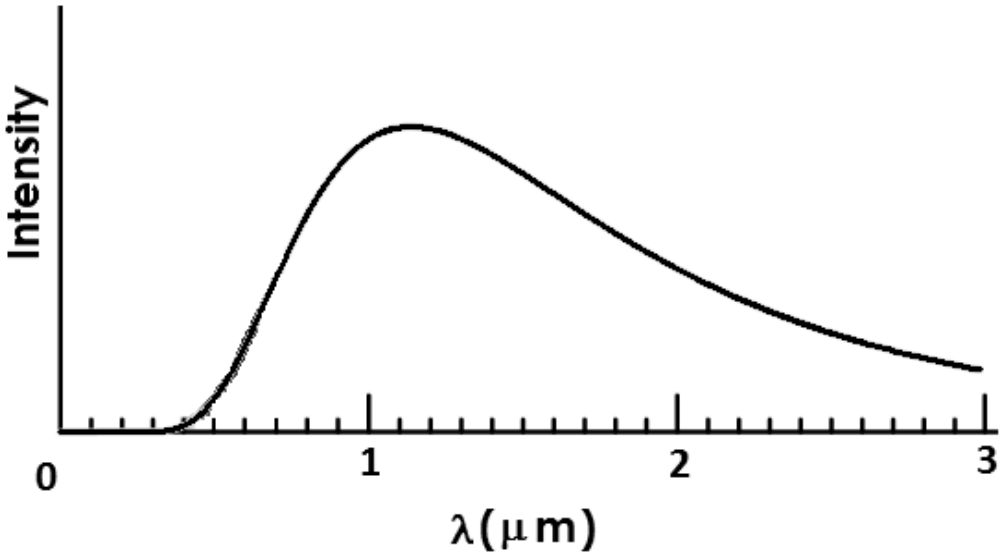
77. Between which 2 numbers on the graph is the SGB?

78. At which number does the first dredge-up occur?

79. At which number does the first helium shell flash occur?

80. Between which 2 numbers on the graph does the planetary nebula form?

A particular symbiotic star system consists of a large post-main sequence giant (star A) and a white dwarf (star B) of 1.00 solar mass. The wavelength distribution of radiation from star A is modeled in the image below. The system displays a parallax of 5.07 milliarcseconds and has an apparent magnitude of 2.09. The stars have an orbital period of 22.5 years and orbit each other at a distance of 11.2 AU. The orbits can be considered circular. Use this information for questions numbered 81 – 89.



81. How far away is this system, in parsecs?

82. (T2) What is the absolute magnitude?

83. What is the effective surface temperature of star A?

84. What is the total mass of the system in solar masses?

85. What is the mass of star A in solar masses?

86. What is the luminosity of star A, in solar luminosities?

87. What is the radius of star A, in solar radii?

88. How far away from star A is the center of mass of the system, in AU?

89. What is the orbital velocity of star A, in km/s?

Numbers 90 −100: Write the word or phrase that best matches the description.

90. Mass loss during pre-main sequence evolution leads to jets of gas which are excited by collisions with the interstellar medium, leading to emission-line spectra

91. The most widely used system to classify planetary nebulae according to appearance

92. (T1) High mass (>2 solar masses) analogs of T-Tauri stars

93. Very large Mira-type stars with hydroxyl maser emission and dust shrouds

94. Subsonic wave front that originates inside a white dwarf, ultimately leading to a Type Ia SN

95. (T8) The class of stars located where the instability strip meets the white dwarf sequence

96. This is responsible for maintaining hydrostatic equilibrium in a white dwarf star

97. The maximum fraction of a star's mass that can exist in an isothermal core and still support the overlying mass layers

98. The number of stars that form per mass interval unit per unit volume

99. Globular cluster classification scheme based on metallicity

100. This method of astronomical distance determination is also called spectroscopic parallax