SCIENCE OLYMPIAD

DIVISION C ASTRONOMY

CAPTAINS TRYOUTS

TEAM NUMBER: _____

TEAM NAME: _____

SCORE: /165

INSTRUCTIONS:

1. Please turn in ALL MATERIALS at the end of the test.
2. Put your TEAM NAME AND NUMBER on every page that you write on.
3. DO NOT write on the questions sheets: only on the answer sheets.
4. This test is out of 165 points, with 36 questions. There will be a combination of short answer, long answer, and multiple choice questions. There are also a few bonus questions, with individual point values listed.

Section 1: Stellar Evolution & Type 1a Supernovae

Instructions: There are 21 multiple choice, fill-in-the-blank questions, and short answer questions, each worth 1 point unless specified otherwise. There are 61 total points in this section. Write or select the best answer.

1) _____ is the last element formed in a star's core through nuclear fusion.

2) The maximum mass of a stable white dwarf star is known as the _____.

3) What is the most rapidly rotating pulsar currently confirmed?
   a) XTE J1739-285
   b) PSR J1748-2446ad
   c) SN 2011fe
   d) J174140

   Bonus: How many rotations per second does this pulsar spin at? (1 point)

4) O-type stars are generally found in the _____ of a galaxy.

5) Explain the carbon-nitrogen-oxygen cycle and how it differs from proton-proton chain reactions, including what types of stars generally use one or the other. (8 points)

6) A star with low to medium mass (0.5 - 8 solar masses) will not be hot enough to fuse _____ into _____, so it will have a _____ core.

7) Given that a certain star lacks a corona and has a convection zone near its core, it is likely to be a type _____ star. Why does this class of stars have a convection zone near its core? (4 points)

8) Why do white dwarfs sometimes experience runaway fusion reactions, and what do these result in? (5 points)

9) Describe the TP-AGB phase of stellar evolution, including where stars derive energy from and different events that occur during it. (7 points)

10) How did population III stars evolve? Explain why their properties allowed them to do so. (5 points)

11) Extreme population I stars are found near the _____ of a galaxy.

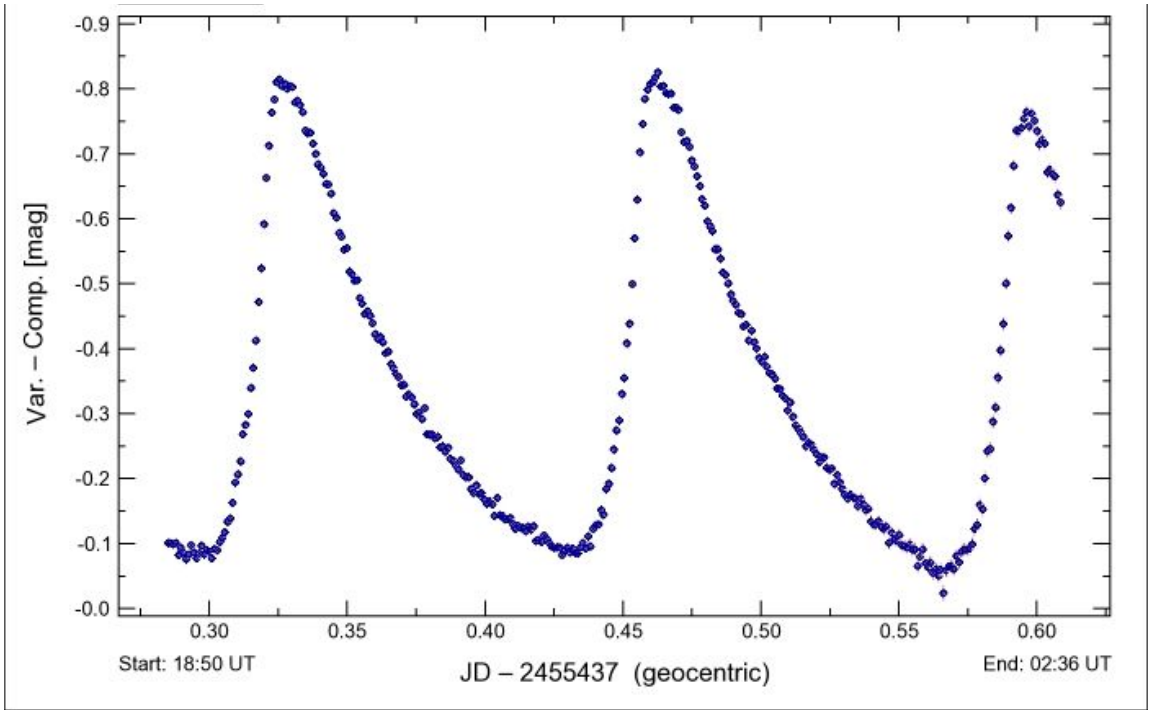
12) Over what part of the electromagnetic spectrum can quasars be detected?
   a) Gamma rays
   b) X-rays
   c) Both a) and b)
   d) The whole spectrum

13) An object whose radius is smaller than its _____ is a black hole.

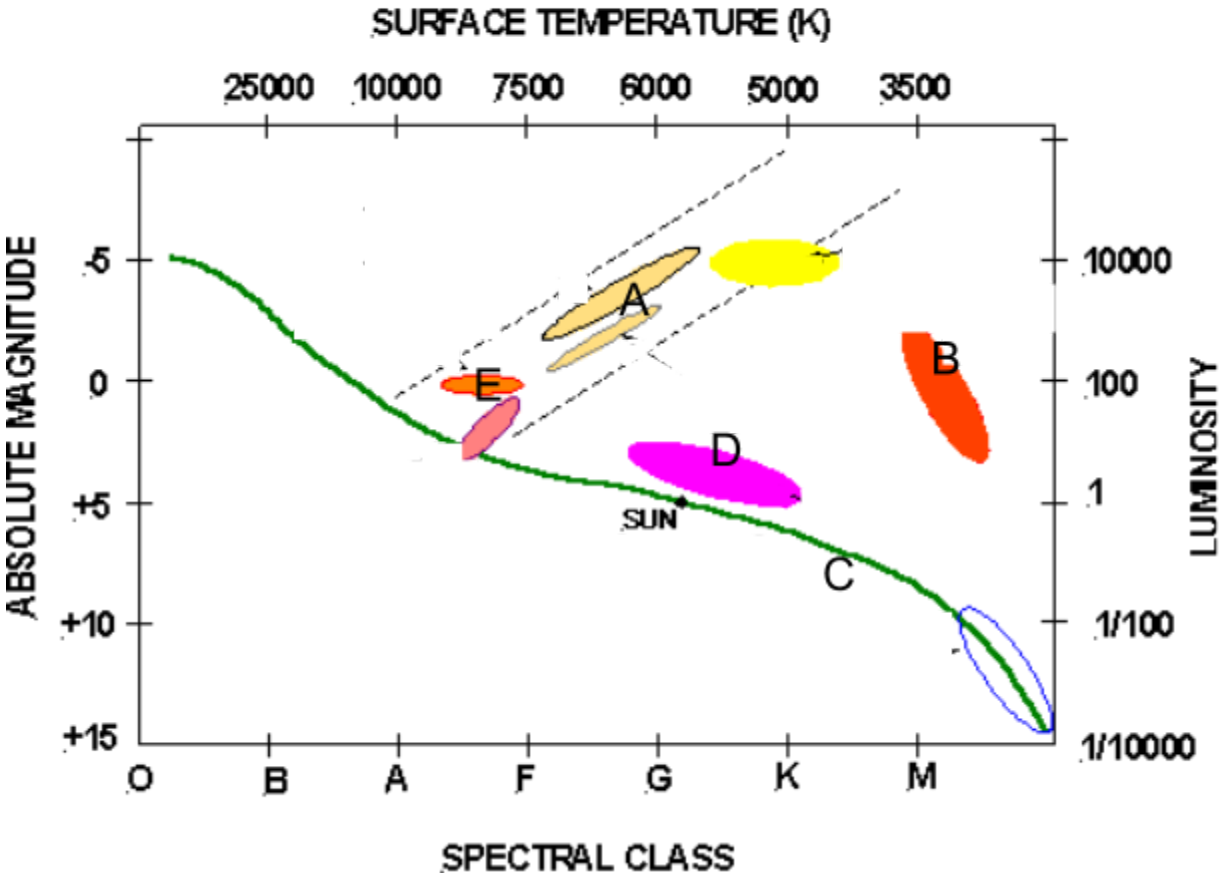
14) A binary system consists of a white dwarf and another companion, and it has an orbital period of about 30 minutes. This is a _____ system in _____ state. (2 points)

15) Compare and contrast the three scenarios in which the system in the above question can form. Be as specific as possible. (16 points)

16) The image below shows the period of a _____ variable star.



Questions 17-21 relate to the H-R diagram below.



17) The area around the letter A is referred to as the _____.

18) The letter B is where _____ variable stars are found.

19) The letter C (referring to the line) is where _____ stars are found.

20) The letter D is where _____ variable stars are found.

21) The letter E is where _____ variable stars are found.

Section 2: Deep Sky Objects

Instructions: This section will test your knowledge about different deep sky objects. There are 13 questions worth 91 points total with individual point values listed. Please refer to the image sheet to see the DSO images.

22) Which DSO is shown in Image A? (5 points)
    a) What is another name for this DSO? Please list as many as you can.
    b) What type of DSO is this object?

23) Which DSO is shown in Image B? (8 points)
    a) Which elements were detected in its spectral signature?
    b) What type of DSO is this object based on its spectral signature?
    c) Why was the light arriving from this DSO 400 years delayed?
    d) What is this delayed light phenomenon called?
    e) Which wavelength(s) is Image B shown in?

24) Which DSO is shown in Image C? (8 points)
    a) When was this object first visible from earth?
    b) What type of object is this?
    c) What is the spectral type of this object's companion star?
    d) Why was the discovery of this object important?
    e) Which wavelength(s) is Image C shown in?

25) Which DSO is shown in Image D? (10 points)
    a) Which type of stellar system is this object?
    b) Why does this object experience dynamic instability in luminosity and size?
    c) In what wavelength does this object emit most of its radiation?
    d) Which wavelength(s) is Image D shown in? Specify if you are describing left or right.

26) Which DSO is shown in Image E? (7 points)
    a) Which survey first observed this deep sky object?
    b) What type of object is this?
    c) Why is the discovery of this object particularly important?
    d) Which wavelength(s) is Image E shown in?

27) Which DSO is shown in Image F? (4 points)
    a) What object is at the center of this DSO, and what is significant about that object?
    b) What does this object's structure suggest about the object at its center?

28) Which DSO is shown in Image G? (5 points)
    a) What type of object is this?
    b) What specifically differentiates this object from other objects of its type? (i.e. why is this object of interest?)

c) Which wavelengths is Image F shown in? Specify if you are describing the left or right.

29) Which DSO is shown in Image H? (6 points)
   a) What types of objects make up this DSO?
   b) Why were scientists initially interested in this DSO?
   c) This DSO is the first _____ system to be confirmed.
   d) What will this DSO become in the next stage of its stellar evolution? In approximately how many years will this happen?

30) Which DSOs are illustrated in Image I (the image represents two DSOs equally accurately)? (7 points)
   a) This DSO is a _____ progenitor. (Give abbreviation and full name, and describe) (3 points)
   b) What are the mass ratios of the two DSOs (specify which DSO each ratio corresponds to)? (2 points)
   c) What wavelengths were these objects observed in? (2 points)

31) Which DSO is shown in Image J? (6 points)
   a) What caused the red outline of this object?
   b) What is significant about the age and evolution of this object? (2 points)
   c) When and what was the peak effective temperature of the central star observed? (2 points)

32) Which DSO is represented in Image K? (6 points)
   a) The larger star in this binary system releases ____ times as much energy as our Sun.
   b) When was the companion star first predicted, and by whom was it predicted? When was it first directly observed, and by whom? (2 points)
   c) What are the two primary elements in the smaller star's core? (2 points)

33) Which DSO's light curve is represented in Image L? (7 points)
   a) What is the orbital period of this system, and what is its significance? (2 points)
   b) In what part of the electromagnetic spectrum was this DSO first detected?
   c) What is the main limitation in observing objects similar to these?
   d) Approximately how much would one cubic centimeter of this object's substance weigh?
   e) The Evolved Laser Interferometer Space Antenna is a proposed observatory. Why is it relevant to this object?

34) Which DSO is shown in Image M? (7 points)
   a) How far away is this object?
   b) How far away did scientists think this object was before 2013? Why did they investigate further and eventually change their conclusion? (2 points)
   c) This DSO is known as a _____ variable.
   d) What causes the variability of this DSO? Explain in detail (3 points)

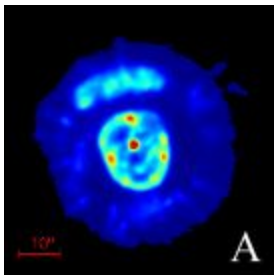
Section 3: Calculations and Math-Related Problems

35) An object is colliding with an exoplanet. Just before hitting the surface of the planet, the object is observed to be accelerating at 6.7 m/s^2. Assume that the object has a negligible effect on the planet's motion. If the diameter of the planet is 26,000 kilometers, calculate the mass of the planet. Give your answer in kilometers, in scientific notation with three significant figures. (3 points)

36) An exoplanet is orbiting a star. The eccentricity of its orbit is 0.6, and the semimajor axis is 0.05 AU. The star is the same mass as our Sun. (10 points)

a) Calculate the semiminor axis of the orbit.
b) Calculate the average radius of the orbit.
c) Calculate the circumference of the orbit.
d) Calculate the velocity of the planet.
e) Calculate the orbital period of the planet.

Image Sheet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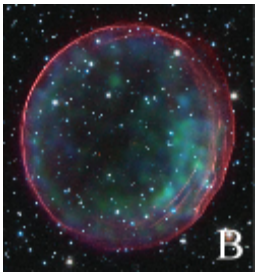
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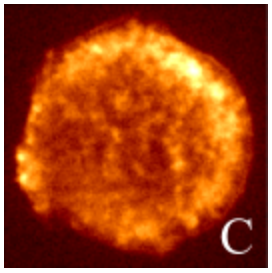
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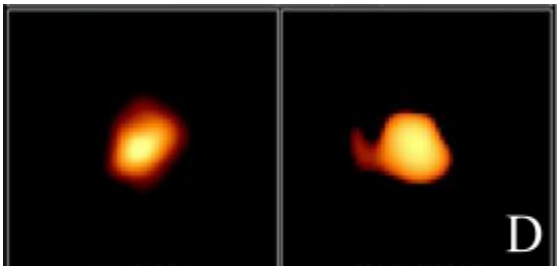
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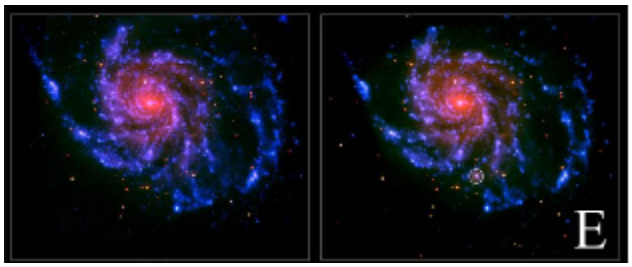
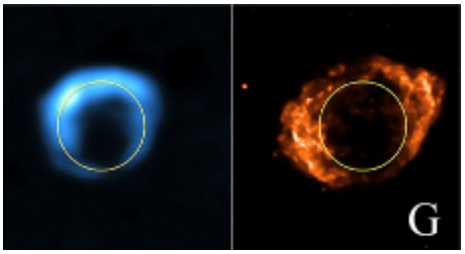
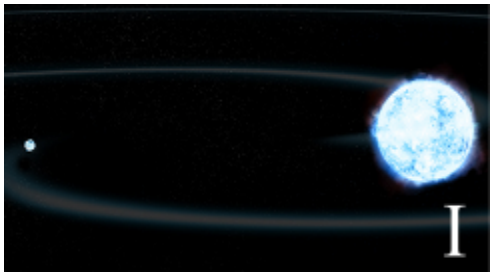
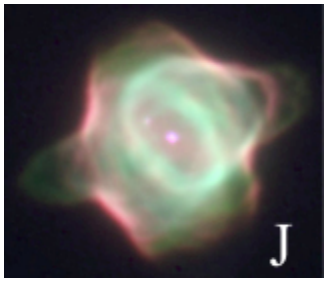

E

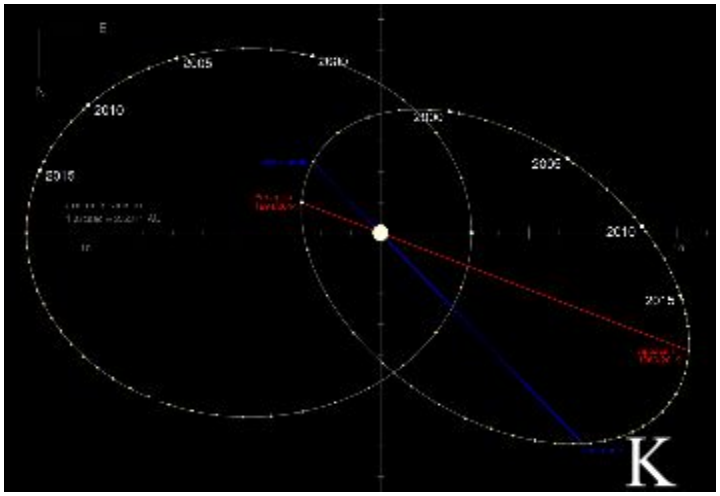

F

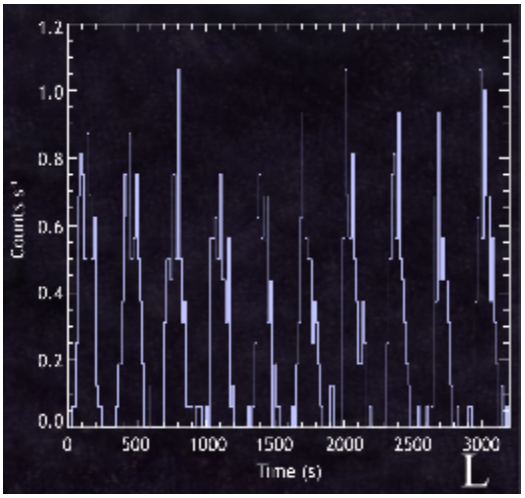

G

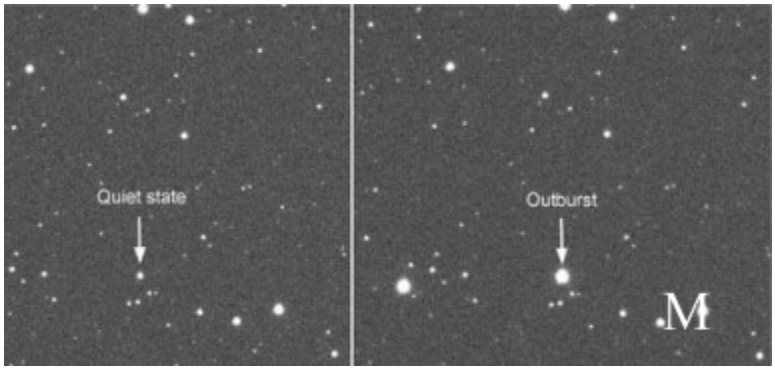

H


I


J


2005
2010
2015
2000
2010
K


1.2
1.0
0.8
0.6
0.4
0.2
0.0
Counts s⁻¹
0
500
1000
1500
2000
2500
3000
Time (s)
L


Quiet state
Outburst
M