

Name _____ Date _____ Moravian Exam _____

The Evolution of Stars—Study Guide

INSTRUCTIONS: **Make sure that your first and your last name and date appear at all applicable locations, yes, even the first page.** This examination is in the form of multiple choice and a few fill-in-the blank questions/statements. After reading the question or instructions carefully, select your answer(s) and mark it (or them) plainly on the answer sheet provided with this test. The answer sheet can be found at the end of the exam. You may detach it. Only answer the odd or even questions depending upon whether your exam number is odd or even. **Take a moment to circle the questions which are your questions throughout the exam.** You may work alone or with **ONE PARTNER** who is taking the other portion of the exam to help each other attain a higher grade. **There will be no communications between teams.** All correct answers must be provided to receive full credit; however, partial credit will be given unless stated otherwise. This exam has a total value of 20 points. **MUCH SUCCESS!**

CANVAS INSTRUCTIONS: This Quest is in the form of multiple-choice questions and a few fill-in-the blanks. After reading the question carefully, select your answer or answers. **If the question calls for multiple answers, two or more, you must provide all answers and all answers must be correct.** Canvas does not allow for partial credit. All answers can be found in the lecture material created in class, the assigned reading material, and the PowerPoint presentations, but if you feel the need to consult online sources, books, or magazines, please feel free to do so. This Quest has a total value of 64 points. **MUCH SUCCESS!!!**

EVOLUTION OF STARS

INSTRUCTIONS: The first 10 questions detail the characteristics of main sequence stars. Your only two answers are **INCREASES** or **DECREASES, “I” or “D”**. Consider the characteristics of stars starting at O₄ and proceeding to M₈. How would the characteristics of the star change as movement occurred from the O class to the M class? A few other questions that follow also will also use the words increases and decreases as answers. They deal with volume, temperature, and rotational speed. In the exam, be mindful of whether the stars start with O₄ or M₈. They could be switched around.

1. O₄ to M₈: The surface temperature of the star...
2. O₄ to M₈: The mass of the star...
3. O₄ to M₈: The time for contraction to zero age main sequence...
4. O₄ to M₈: The luminosity of the star...
5. O₄ to M₈: The absolute magnitude of the star...

6. O4 to M8: The life expectancy of the star...
7. O4 to M8: The physical size of the star...
8. As the volume of a gas cloud decreases, the density of that gas cloud will...
9. A gas cloud starts with a certain temperature and with a slight rotational motion. If there is sufficient mass and the cloud begins to contract to form a star, the temperature of that cloud will begin to... Think of the Fahrenheit 451 experiment (the tube and plunger).
[Key Concepts: The characteristics of main sequence stars on the H-R diagram are tested here.](#)
10. A gas cloud begins with a certain temperature and a slight rotational motion. If there is a sufficient mass and the cloud begins to contract, the rotational speed of the cloud will begin to... Think of an ice skater performing a spin.
[Key Concept: Early evolution of stars... What happens to the nebular cloud gas and dust as it contracts to form a star? Angular momentum...](#)

End of increase/decrease “I” “D” questions...

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11. If two identical sodium vapor streetlights are viewed simultaneously from a distance of one city block (1/8 mile) and two miles respectively, the streetlamp at a distance of one block (1/8 mile) will appear how many times brighter than the lamp two miles distant?
[Key Concept: Inverse square law tells it all, \$I = 1/d^2\$.](#)
 12. The magnitude scale quantified in the 19th century was first used by the Greeks two thousand years ago. Choose the **CORRECT** statement.
[Key Concept: Understand how astronomers quantify the brightnesses of the stars.](#)
 13. The star with the brightest absolute magnitude in the list is
[Key Concept: Understand the nonintuitive aspect of stellar brightnesses with respect to positive and negative magnitude as well as the definition of absolute magnitude.](#)
 14. The star with the brightest apparent magnitude as viewed from the Earth in the following list is
[Key Concept: Understand the definition of apparent magnitude and magnitude system in general including its major misconceptions.](#)
 15. Until the 19th century (early 1800s), it was impossible to compare the true brightness of the stars with each other because
[Key Concept: Understand how Frederik Bessel's ability to find the parallax of a nearby star played a key role in learning about the true nature of the stars. There is a slide about Bessel.](#)

16. Which list gives the correct ordering of the various parts of the electromagnetic spectrum from **highest frequency to lowest frequency**? Not all of the energies of the electromagnetic spectrum are represented in each list.
Key Concept: Understand how the number of wave crests passing a position each second (frequency) plays a role in defining their energies. State the different parts of the electromagnetic spectrum in their correct order according to frequency. There is a slide about Max Planck.
17. Which list gives the correct ordering of the various parts of the electromagnetic spectrum from **most energetic to least energetic**? Not all of the energies of the electromagnetic spectrum are represented in each list.
Key Concept: Know the correct ordering of the various parts of the electromagnetic spectrum with respect to energy and wavelengths. What is the relationship between energy and wavelength according to Max Planck?
18. Which list gives the correct ordering of the various parts of the electromagnetic spectrum from **longest wavelength to shortest wavelength**? Not all of the energies of the electromagnetic spectrum are represented in each list.
Key Concept: Be able to state the different parts of the electromagnetic spectrum in order of wavelengths.
19. Which one of the following forms of energy is not part of the electromagnetic spectrum?
Key Concept: Understand the different terminologies for the wave and particle descriptions of electromagnetic radiation.
20. How were the various gasses that were fluoresced in the emission spectra lab important to understanding the composition and temperature of the stars?
Key Concept: Why are laboratory experiment conducted with fluorescing gasses to understand absorption spectra? What is the relationship between emission and absorption spectra of the same element or compound?
21. There are two basic descriptions of light. Which word relating to one of these descriptions does not belong in the following list?
Key Concept: Understand that the light (electromagnetic radiation) can be described as an ocean wave, but light striking a light sensitive surface must be described like a Ping-Pong ball.
22. The speed of the various energies of the electromagnetic spectrum is always
Key Concept: What does all electromagnetic radiation have in common?
23. When the speed of light slows because the electromagnetic energy has passed from a less dense medium to a denser medium, the light is said to be bent or
Key Concept: Descriptively understand Snell's Law.

24. **Pick two correct answers.** Black body radiation curves allow astronomers to:
Key Concept: Understand the black body radiation curves of stars of different temperatures. It is one of the most important slides in Becker's PowerPoint program. **It should be consulted whenever a black body radiate question arises.**
25. The following statements are true. The sun's surface temperature is 5778 K. If that number is plugged into Wein's Law, the wavelength of light that the sun most frequently emits is at 5016 Angstroms or 501.6 nanometers. This wavelength converted into a color is basically green. Why is the sun observed as a basically a white star?
Key Concept: Understand Wein's Law, the characteristics of black body radiation curves for stars of different temperatures, and how colors blend in an additive sense.
26. Star A is hotter than star B. Star A will
Key Concept: Understand the characteristics of black body radiation curves for stars of different temperatures and how they are graphically represented.
27. The sun's blackbody radiation curve peaks in the green, right in the middle of the visible spectrum of colors. Why is the sun not a green star?
Key Concept: Understand what happens when all of the visible color of the spectrum are added together and apply this to a blackbody radiation curve that peaks in the green, like our sun.
28. According to the Bohr Theory of the atom, when a specific quanta or energy is absorbed by an electron,
Key Concept: Understand how Niels Bohr explained fluorescence and absorption. Remember the glow tubes that we fluoresced in the Emission Spectrum Lab. Energy wise, what does the electron do when it absorbs a specific energy kick?
29. If an electron in a hydrogen atom were to jump from the $n = 3$ level to the $n = 2$ level,
Key Concept: Understand how the energy of an electron changes when it jumps from a higher orbital to a lower orbital. The $n=2$ level is very significant for the hydrogen atom because some of the downward transitions produce visible light.
30. Standing near a lightbulb with a tungsten filament shining at a blackbody radiation temperature of 2700 K.
Key Concept: Understand Kirchhoff three laws of spectroscopy, and the most frequently emitted energy from blackbody radiation curves of different temperatures.
31. A star with a blackbody radiation curve of 2700 K.
Key Concept: Understand Kirchhoff three laws of spectroscopy, and the most frequently emitted energy from blackbody radiation curves of different temperatures.
32. The basis behind absorption spectroscopy or the formation of the absorption spectrum is
Key Concept: Understand Kirchhoff three laws of spectroscopy, but particularly the third law in this instance.

33. Analyzing the absorption spectrums of the stars can tell astronomers what important facts?
Key Concept: Absorption lines found in a spectrum qualifies/quantifies what key facts about the star being observed?
34. The spectral classification of a star that falls along the main sequence of the Hertzsprung-Russell diagram, **FAILS** to tell astronomers which one of the following characteristics about that star.
Key Concept: Understand what the “X” and “Y” axes of an H-R diagram represent. The position of a star on the main sequence tells astronomers what characteristics about the star?
35. The spectral classification of main sequence, O, B, A, F, G, K, M stars are best described as _____ sequence.
Key Concept: Understand the spectral characteristics of O, B, A, F, G, K, and M stars. The spectral classification of stars also represents the X-axis of the Hertzsprung-Russell diagram.
36. According to the spectral classification pairs given below, which two stars represent the greatest differences in temperature?
Key Concept: Understand the temperature ranges of each of the spectral types (O, B, A, F, G, K, and M) is greater for hotter stars and less for cooler stars.
37. The relative strength of the dark absorption lines of stellar spectra are
Key Concept: The strengths of absorption lines are a function of what property of a star?
38. To classify a star in the OBAFGKM system with the greatest accuracy
Key Concept: Understand that the spectral line strengths of different elements vary with temperature and that by comparing line strengths of standard elements to one another the temperature of a star may be obtained.
39. When a spectrogram of the sun is examined, it is found that the darkest absorption lines that are present result from singly ionized calcium, neutral iron, and neutral magnesium. Hydrogen is prominent, but not dominant. What does this tell you about the sun?
Key Concept: Absorption lines strengths are a function of what property of a star?
40. The existence of compounds in the spectrum of a star would indicate that this star is
Key Concept: Molecular bonds are weaker than the bonds between electrons and the nucleus of an atom. Molecules that form in the atmospheres of star, represent a key indicator of what characteristic of that star?

41. The most massive stars known are approximately how many times more massive than the sun? This does not include hypergiant stars.
[Key Concept:](#) Understand that there are limits to the mass of stars, both high and low, just like there are limits to the human family.
42. A star with 30 times the mass of the sun would
[Key Concept:](#) How does the mass of a star affects its lifespan?
43. The brightest star listed below would be at a magnitude of
[Key Concept:](#) Understand key concepts in the magnitude system for measuring the brightness of stars.
44. The brightest star listed below would be at an absolute magnitude of
[Key Concept:](#) Understand the differences between absolute and apparent magnitudes.
45. When the three bright stars of the Great Summer Triangle were compared in the laboratory exercise completed in class, it was discovered that
[Key Concept:](#) In order to make comparisons of objects that we believe have similar characteristics, we must observe them from the same distance.
46. If star A is five magnitudes brighter than star B. The brightness of star A is how many times greater than star B? A difference of one magnitude equals an intensity difference of 2.51.
[Key Concept:](#) Understand key concepts of the non-intuitive magnitude system for measuring the brightness of stars.
47. The absolute magnitude of a star is
[Key Concept:](#) Know the definition for absolute magnitude.
48. Pick the best answer. The absolute magnitude of a star allows astronomers to easily understand that star's
[Key Concept:](#) Know the definition for absolute magnitude and understanding why it is significant in understanding the characteristics of stars.
49. One parsec is a unit of distance that is equivalent to
[Key Concept:](#) Know the definition of a parsec.
50. Consider two stars. The temperature of one of the stars is twice as great as the temperature of the second star. Which statement is true?
[Key Concept:](#) Understand what black body radiation curves tell us about the property of stars.

51. The most numerous grouping of stars on the main sequence in the Milky Way galaxy, or for that matter the universe, is found to be of spectral classification
Key Concept: Which main sequence stars are the most abundant?
52. The spectral classifications of the stars that are lighting up the bluish arms of spiral galaxies like the Milky Way are
Key Concept: Understand how the luminosities and spectral types of stars could affect the color of a galaxy. Consider the image of the Cartwheel Galaxy shown to you in class and consider why the “wheel” looks bluish.
53. Find the **INCORRECT** statement. The Hertzsprung-Russell diagram charts the
Key Concept: What do the “X” and “Y” axes of the H-R diagram represent?
54. The Hertzsprung-Russell diagram allows astronomers to understand
Key Concept: Understand the meaning of the “X” and “Y” axes of the H-R diagram and their interrelationship to each other.
55. The Hertzsprung-Russell diagram plots what against what?
Key Concept: Understand the meaning of the “X” and “Y” axes of the H-R diagram and their interrelationship to each other.
56. In astronomy, when the term “burning” is used in relation to stars, it really means
Key Concept: Energy production in stars is referred to by astronomy as “burning.” What does that concept really mean in astronomy?
57. Stars that are "burning" hydrogen into helium as their main energy source are found exclusively on the
Key Concept: Understand the luminosity/spectral classifications of star, how stars create their energy in their cores, and why stars are found in a specific location on the H-R diagram.
58. The position of a main sequence star on an H-R diagram is a result of that star's
Key Concept: The luminosity/spectral classification of a main sequence star on the main sequence is related directly to what specific property of that star?
59. Stars that are very cool, but extremely luminous are called _____. (Place your answer on the answer sheet).
Key Concept: Understand the concepts about the different basic luminosity classifications of stars on the H-R diagram and what they uncover about a star’s physical characteristics.

60. Stars that are very faint, but have high surface temperatures are called _____ (Place your answer on the answer sheet).
[Key Concept:](#) Understand basic concepts about luminosity classifications of stars on the H-R diagram and what they reveal about a star's physical characteristics.
61. Stars that are very luminous, and have high surface temperatures are called _____ (Place your answer on the answer sheet).
[Key Concept:](#) Understand basic concepts about luminosity classifications of the H-R diagram.
62. State the name of the brightest (apparent magnitude) main sequence star in the sky _____ (Place your answer on the answer sheet).
[Key Concept:](#) Understand the definition for apparent magnitude and the answer will become apparent.

**A picture of a Hertzsprung-Russell diagram with
specific stars goes here!**

INSTRUCTIONS: Make use of this H-R diagram from question 60 through question 72. The same star may be used multiple times.

[Key Concept:](#) Understand how Hertzsprung-Russell diagram can provide information about the evolution of the stars.

63. Which one of the named stars listed below has the highest absolute luminosity?
64. Which one of the named white dwarf stars might be assumed to be the oldest?
65. Which of the named stars listed below are undergoing core hydrogen burning?
66. Name the stars which are burning helium or heavier elements as fuels?
67. Which one of the named stars listed is closest to death?
68. What condition causes blue stars in the upper left of the H-R diagram to be extremely luminous?
69. Which one of the named stars below has the lowest luminosity?
70. The white dwarf star possessing the lowest luminosity is dimmest because of its surface temperature or its size?

71. Which one of the named stars has the highest surface temperature?
72. What will be the ultimate fate of the three main sequence stars named in the H-R diagram?
73. Was Procyon B ever a main sequence star?
74. Predict the next life stage into which the star Vega will evolve?
75. At 19 solar masses, what will be the ultimate fate of Deneb as a dead star?
76. A shock front
Key Concept: What is a shock front? Understand the key properties of a shock front.
77. Which of the following events could realistically **trigger** the formation of a star cluster? You are required to state **two** of them.
Key Concept: Understand the manner in which a shock front is created and how this influences the formation of star clusters like the Pleiades or the Orion nebula.
78. Pick the **INCORRECT** answer. When a star cluster is formed through a shock front mechanism,
Key Concept: Understand the concept of a shock front and the sequence of stellar evolution in star clusters like the Pleiades or the Orion nebula.
79. Which statement about the Orion nebula is **FALSE**?
Key Concept: What is really happening inside the Orion nebula?
80. During the very early phases of a star's formation, its energy comes from
Key Concept: Understand the perfect gas laws as a huge cloud of gas and dust contracts. Remember the fire piston demonstration in one of the beginning lessons.
81. When a new star is forming, what is the event that halts the process of contraction?
Key Concept: Understand the different key steps in the formation of a star like the sun.
82. Thermonuclear fusion is just another way of saying
Key Concept: Consider what is happening inside the core of a star at the most fundamental level so that a star can shine.
83. Lower mass stars, like our sun, contract onto the main sequence and then change ever so slowly during their lives on the main sequence. At the position of a zero-age main sequence star like our sun, its luminosity is
Key Concept: Since the main sequence has thickness, qualitatively, where did the sun start its hydrogen fusion on the main sequence? Think luminosity and temperature.

84. Lower mass stars, like our sun, contract onto the main sequence and then change ever so slowly during their lives. By the time that the star is ready to leave the main sequence, it has become
Key Concept: Since the main sequence has thickness, qualitatively, where will the sun end its hydrogen fusion on the main sequence? Think luminosity and temperature.
85. Size-wise, a star that has become slightly cooler but more luminous changes in what way with respect to size.
Key Concept: Since the main sequence has thickness, quantitatively this should affect a star's size during its lifetime on the main sequence!
86. The event that marks the end of a star's existence on the main sequence occurs when the star begins to burn hydrogen in a
Key Concept: Understand the different steps in the evolution of a star like our sun.
87. When a low mass star evolves from the main sequence into its red giant phase,
Key Concept: Consider what changes are occurring in the core of a star when it evolves into a red giant
88. When a low mass star similar to our sun ascends to the red giant region of the H-R diagram, an event known as the helium flash may occur. The helium core is degenerate. It does not obey the perfect gas laws (volume of gas expands when heated, contracts when cooled). When helium burning begins, it rips through the star's core, but not much happens. Eventually, so much energy gets released from the ongoing helium fusion that the core material is rapidly expanded out of its state of degeneracy. This slows the helium burning in the core of the star and causes the star to become
Key Concept: Where will a star migrate on the H-R diagram after the helium flash? It backtracks, doesn't it? Think about the changes in luminosity and temperature of the star when this occurs.
89. When a massive star ascends into the supergiant branch, the extreme upper right area of the H-R diagram, this means that
Key Concept: Understand how massive stars keep spontaneously inventing new thermonuclear processes to sustain themselves against gravitational collapse. Think of the core of a massive star looking like an onion.
90. Examining the H-R diagram shows that there are few stars in the giant and supergiant categories. What causes this situation to occur?
Key Concept: Understand the percentage of time that stars remain in certain locations on the H-R diagram, i.e., undergoing certain thermonuclear processes within their cores.

91. Inspecting the H-R diagram shows that there are few stars in the white dwarf category. Why is this true?
Key Concept: Understand how distance affects the visibility of high luminosity stars that are very small.
92. After leaving the main sequence, the sun will first evolve into a
Key Concept: Understand the evolution of relatively low mass stars like our sun. A good example of the sun's future fate might be Aldebaran in the constellation of Taurus the Bull.
93. Our sun will eventually have an inert helium core surrounded by a thinning, less stable shell of hydrogen gas that is undergoing thermonuclear fusion. This will cause the sun to become a
Key Concept: Understand the changes in thermonuclear fusion in relatively low mass stars like our sun as they evolve off the main sequence when hydrogen in their cores is depleted.
94. The end stage in the evolution of a star similar to our sun will cause it to become a
Key Concept: Understand the final evolutionary sequence of a solar mass star.
95. Find one **astronomically INCORRECT** statement about white dwarf stars.
Key Concept: Interpret the meaning of the location of white dwarfs on an H-R diagram.
96. Astronomers currently believe that elements more massive than iron are created in
Key Concept: Understand the last step in the evolution of very massive stars.
97. Six billion years ago, the heavier atoms found in your body were most probably
Key Concept: Where are the heavier elements formed and how do they seed the universe? Is our sun a first generation star?
98. Whether a star sits at the upper left-hand corner of the main sequence or the lower right hand corner of the main sequence or as a white dwarf or as a red supergiant depends upon that stars.
Key Concept: One concept governs a star's location on the Hertzsprung-Russell diagram?
99. Whether a star becomes a white dwarf, a neutron star, or a black hole is dependent upon its remaining
Key Concept: One concept governs a star's location on the Hertzsprung-Russell diagram?
100. In order for a star or an object to evolve into a black hole or a black hole in a binary system...
Key Concept: Understand how the amount of mass that remains after the death of a star can affect the end of it evolutionary life. Why will the sun after its death never become a black hole?

101. An astronomer plots the appropriate characteristics of many stars in a cluster to create an H-R diagram. She/he finds that the most luminous O and B stars have reached the main sequence, but that the F, G, K, and M stars have not yet reached the main sequence. From this information the astronomer can conclude that

Key Concept: How does the mass of a star affect its length of time in becoming a star, and what can this tell us about the age of a star cluster?

102. Two stars are revolving around each other in a binary system. The one star is a 20-solar mass red supergiant while the other luminary is a neutron star. The two stars were at no time in physical contact to exchange any matter with each other. It is fair to say

Key Concept: How does the mass of a star affect the speed of its evolutionary sequence?

103. State in order from smallest to largest the sizes of the following objects that you classified in the homework assignment, "Identify the Celestial Object." Consider a galaxy, a star, a globular cluster, a planetary nebula or supernova, and an open cluster.

Key Concept: Know the relative size differences between stars, galaxies, globular clusters, open clusters, nebulae, and planets.

- 104-108. The following five questions will be presented with images containing one or more of the following objects listed below. Choose the correct object that the picture portrays to receive credit.

- | | | |
|----------------------|-----------------------|-----------------------|
| a. Star cluster. | e. Star field. | i. Planetary nebula. |
| b. Spiral galaxy. | f. Elliptical galaxy. | j. Supernova remnant. |
| c. Globular cluster. | g. Irregular galaxy. | |
| d. Dark nebula. | h. Emission nebula. | |

Key Concept: Understand what different types of astronomical object look like. Hint: Take these answers and put them into Google images to understand how these images look if you are having trouble with their visualization.

109. The Hertzsprung-Russell diagram is a two dimensional representation (x and y axes) that led astronomers to a fundamental understanding of a star's

Key Concept: Star just being born, main sequence stars, red giants and red supergiants, white dwarfs and supernovas, all tell a story that the Hertzsprung-Russell diagram has been used to explain.

110. In order to comprehend the true luminosity or brightness of a star, it was first necessary to understand that star's

Key Concept: If you were trying to examine a group of people far and near, it would be best if they were all observed from the same _____.

111. While the O, B, A, F, G, K, M classification system could have been made simpler (A, B, C, D, E, F, G), it identifies on the Hertzsprung-Russell diagram the Key Concept: These letters another way of expressing these letters is through the _____ of a star.
112. Absorption spectroscopy, where dark lines superimposed over the continuum (rainbow or colors), was the key to understanding a star's Key Concept: Think of the line intensity ratios of the absorption spectrum lab that we completed where we classified 30 stars. Why are the H and K lines of singly ionized calcium darkest when the sun contains mostly hydrogen and helium?
113. A star like Rigel in the constellation of Orion, a B8 bright supergiant, radiates most of its energy in the _____ part of the electromagnetic spectrum. Key Concept: Examine a blackbody radiation curve for a very hot star like Rigel and the answer should become apparent. Rigel's surface temperature is around 18,000 K.
114. A star like Betelgeuse in the constellation of Orion, an M2 supergiant would be radiating most of its energy in the Key Concept: A blackbody radiation curve for a cool star will make this answer very clear. Find λ_{max} for a star around 3200 K.
115. You hug your significant other and suddenly a reduction in your stress levels occurs as well as the absorption of Key Concept: We actually calculated the most common wavelength of energy emitted by the human body. It was somewhere around 94,000 Angstroms.
116. What part of the electromagnetic spectrum does the sun emit most of its energy? Key Concept: The sun radiates its greatest amount of energy in the green. Check a blackbody radiation curve for a star like this.

April 26, 2025