Astronomy 0113: Exam 3 [FINAL]

11-Dec-1995

Please write clearly. Marks will be deducted for untidy work. Questions may be done in any order but they **must be labelled clearly**. Leave a few lines between each question. The marks for each question are indicated.

In Section A, only the answer need be given unless explicitly stated otherwise. If a justification is needed, it need only be a few lines long.

Questions in Sections B and C require a longer answer, and are worth more. A simple answer for these questions will **NOT** suffice — **you must indicate your reasoning**. All working must be shown, and units must be provided for the final answer. Partial marks will be awarded for incomplete or incorrect answers. If you feel that your answer is incorrect because you may have made some mistake, indicate why you think this.

The EXAM is worth a total of 140 marks.

Section A [**50 marks**]

1. Star A has an apparent magnitude of 6, and star B has an apparent magnitude of 4. Which star appears brighter, and by what factor?

   (2 marks)

2. A photon has a particular wavelength when emitted from a star. However, when we observe the photon its wavelength will, in general, be different. Name two effects which can alter the perceived wavelength of a photon ?

   (2 marks)

3. The Milky Way Galaxy is an example of what type of galaxy?

   (2 marks)

4. From what source does a White Dwarf star obtain its energy?

   (2 marks)

5. What is the Right Ascension of the Vernal Equinox?

   (2 marks)

6. What effectively limits the angular resolution of a ground based optical telescope? (1 or 2 words). What is the size of this typical angular resolution?

   (2 marks)

7. A star is observed to have a parallax of 0.02 arcseconds. What is its distance?

   (2 marks)

8. A galaxy has a luminosity of $10^{11}\,L_{\odot}$. From its morphological properties we know that such a galaxy generally has a mass-to-light ratio of 10. What is the "best" estimate for the galaxy's mass?

   (2 marks)

9. Stars with ages greater than 10^{10} years and which lie in the Halo of our galaxy are termed Population ? stars. They have metallicities [greater, similar, smaller] (choose one) than the Sun. (2 marks)

10. What is the most important difference between normal gas pressure and electron degeneracy pressure? (Hint: this difference explains why the onset of helium burning occurs explosively [i.e., the Helium flash] in a $1\,M_{\odot}$ red giant.) (2 marks)

11. At what moon phase or phases does a Solar Eclipse occur? (2 marks)

12. The microwave background radiation is observed to have a dipole anisotropy (i.e., is brighter in one quadrant [quarter] of the sky, and fainter in the opposite quadrant). This anisotropy is due to? (2 marks)

13. Why are eclipsing binaries important? (2 marks)

14. A star has a temperature of 100,000 K. At what wavelength does its energy distribution peak? (3 marks)

15. Your weight on Earth is 1000N. What would your weight be on a planet with a radius 3 times that of Earth, but with the same mass as Earth? What would be the change in your mass? (3 marks)

16. The lifetime of a $1\,M_{\odot}$ star on the main sequence is approximately 10^{10} years. Which of the following [3×10^{12} years, 4×10^{10} years, 10^{10} years, 3×10^{8} years] would be the best estimate of the lifetime on the main sequence of a star with mass of $4\,M_{\odot}$. Indicate the reason for your answer. (1+2 marks)

17. A star is rotating at 1 revolution per month. If its radius contracts by a factor of 10, what would its new rotation rate be? What conservation law is being used? (Apart from the change in radius, assume that the mass and structure of the star are unaltered.) (2+1 marks)

18. A distant galaxy is observed to have a radial velocity of $2000\,\mathrm{km\,s^{-1}}$. Is the galaxy moving towards us or away from us? What is the galaxy's distance? What is the name of the law you used to derive this distance? (4 marks)

19. What does the following equation describe? Define all terms.

$$P = nkT$$

(4 marks)

20. What would be the angular diameter of the Sun if it were located at a distance of 1 kpc? Show your working. (4 marks)

Section B [30 marks]

Answer only 5 of the following 6 questions.

21. Star A, in the absence of interstellar extinction, would have an apparent visual magnitude of 12. If it suffers 2 magnitudes of interstellar extinction in the visual, what is its apparent visual magnitude?

    Suppose the same star, in the absence of interstellar extinction, would have an apparent UV (ultraviolet) magnitude of 12. Which of the following magnitudes would best describe its apparent UV magnitude [8, 11.5, 12.5, 14, 16] in the presence of 2 magnitudes of VISUAL extinction? Explain you reasoning. [Hint: What is the alternate name for interstellar extinction?]

    (6 marks)

22. Suppose a star is located at a distance of 10 kpc. If the star were moved to a distance of 5 kpc, how much more/less energy would an observer on Earth receive? What would be the difference in magnitude? If the star has an ABSOLUTE magnitude of 6 at 10 kpc, what is its ABSOLUTE magnitude at 5 kpc?

    (6 marks)

23. The Joule is the SI unit for energy, and is defined as 1 Joule=1 $\mathrm{kg\,m^2\,s^{-2}}$. The erg is the cgs unit of energy, and is defined by 1 erg=1 $\mathrm{gm\,cm^2\,s^{-2}}$. Derive the relationship between the Joule and the erg. Define all conversions used.

    (6 marks)

24. A photon has a frequency of 5.0×10^{13} Hz. What is the photon's wavelength and energy? In what spectral band does the photon lie?

    (6 marks)

25. Compare the luminosity of Star A (Radius=$10R_\odot$, Mass=$2.5M_\odot$, $T_{\rm sur} = 5,000\,\mathrm{K}$)) with the luminosity of Star B (Radius=$2.5R_\odot$, Mass=$3.0M_\odot$, $T_{\rm sur} = 10,000\,\mathrm{K}$),

    (6 marks)

26. What is the minimum central pressure of a White Dwarf which has a mass of $1M_\odot$. Assume its radius is identical to that of the Earth. What equation (i.e., the Equation of ? ?) was used to derive (in class) the formula for the minimum central pressure? (6 marks)

Section C [60 marks]

Answer only 5 of the following 9 questions.

27. What is the Schwarzschild radius of a $10\,M_\odot$ black hole? What is the average density inside the volume defined by the Schwarzschild radius? Why is the Schwarzschild radius important? What does the term singularity refer to?

(12 marks)

28. What is a galaxy? Describe the differences between Elliptical and Spiral Galaxies.

What is a supernova? Discuss the difference between Type I and Type II supernovae?

(6+6 marks)

29. List 3 reasons why clusters of stars are useful for studying stellar evolution. List at least 3 differences between Globular clusters and Open clusters. Be careful that you clearly indicate what property belongs with what cluster. You may like to do a parallel list. (6+6 marks)

30. What is the rotation curve of a galaxy, and why is it useful? Draw a rotation curve which is continuous, and has the following properties. Shows solid body rotation between 0 and 20 kpc. Has a flat (i.e. constant) rotation (orbital) velocity of $200\,\mathrm{km\,s^{-1}}$ between 20 and 50 kpc. Between 50 and 200 kpc the rotation velocity has the form $v_{\mathrm{rot}} = 200\sqrt{(50\,\mathrm{kpc}/r)}$. You should label both axes for r = 0, 20, 50, and 200 kpc.

What does the falloff in the rotation velocity beyond 50 kpc indicate? [Hint: Look at the expression for V_{orb} in the formulae summary].

(12 marks)

31. Draw a diagram showing the structure of the Sun. You should indicate all of the following: photosphere, corona, chromosphere, core, radiative zone, convective zone. Provide a brief (1 to 3 line) description of each. (12 marks)

32. Define and discuss **ANY TWO** of the following: Steady-State Theory, Big-Bang Theory, Microwave Background Radiation, Expansion of the Universe.

(6+6 marks)

33. Discuss the evolution of a $1M_\odot$ star beginning from the Main Sequence. Some of the areas you may like to discuss are time scales (qualitatively only), energy sources, the driving mechanism behind each (or some) of the evolutionary steps, and the nature (e.g. central star of planetary nebula, red giant) at some important stages in the star's evolution. Show the evolution on a H-R diagram labelling important locations.

(12 marks)

34. Write a paragraph on each of the following: White Dwarf stars, Neutron stars and Pulsars, Black Holes. Some of things that might be discussed are properties, how they arise in stellar evolution, and how you might detect each object. You should indicate what the Chandrasekhar Mass is.

(4+4+4 marks)

35. A planet orbits a Star of mass $3\,M_{\odot}$. At closest approach to the star (perihelion) the planet is at 4 A.U., while at its furtherest distance (aphelion) it is at a distance of 6 A.U. What is the shape of its orbit? What is the orbital period of the planet expressed in Earth years?

A photon with frequency 1.0×10^{15} Hz is emitted from the surface of a stationary Neutron star (R=10km, M=$1.0\,M_{\odot}$). At what frequency do we observe the photon.

(6+6 marks)