Exam 03: Chapters 09 and 10

Data for Several Well-Known Stars

Star	Parallax (arcsec)	Apparent Magnitude	Absolute Magnitude	(B–V)	Spectral Type	Luminosity (L/L⊙)
Deneb	0.0023	+1.25	–8.38	+0.09	A2 Ia	196,000
Aldebaran	0.051	–2.10	–0.63	+1.54	K5 III	518
Tau Ceti	0.274	+3.50	+5.69	+0.72	G8.5 V	0.52
Spica	0.012	+0.98	–3.50	–0.13	B1 V	2,200
Procyon	0.286	+0.40	+2.70	+0.40	F5 V	7.2
Betelgeuse	0.005	+0.42	–6.02	+1.85	M2 Iab	120,000

1. Where do sunspots form with the greatest frequency?
   A) Between 0° and 30° N or S solar latitude.
   B) Between 60° and 90° N or S solar latitude.
   C) At the poles (90°N or 90°S solar latitude).
   D) 0°. Sunspots only form on the solar equator.

2. Which of the following accurately describes sunspot formation?
   A) Sunspots form randomly, but there is always a constant number. If one spot disappears, another forms to replace it.
   B) The number of sunspots may not remain constant, but the surface area of the sun covered by sunspots does. There may be many small spots, or a few large ones, but they always cover precisely 1% of the visible surface area of the sun.
   C) Both the number of spots and the surface area of the sun they cover remains constant. Sunspots are an extremely stable, static feature of the sun.
   D) The number of spots varies, as does their size and surface area covered. The sun goes through periods of greater sunspot formation followed by periods of reduced sunspot activity.

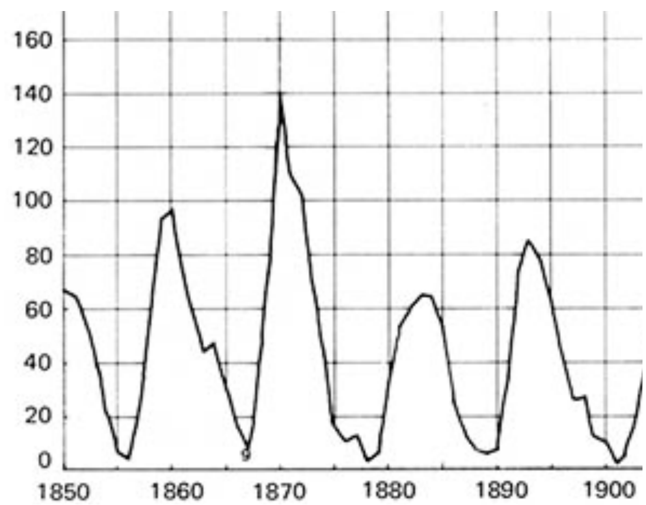
3. Why does a sunspot appear dark?
   A) Because it is made of gas and dust that absorbs visible light.
   B) A dark sunspot is cooler than the surrounding areas on the sun's surface.
   C) The spots are openings, or holes, through which the sun's interior can be seen. It's dark in there!
   D) This is another optical illusion caused by viewing the sun through the Earth's atmosphere. Sunspots are not visible from space.

4. Why do sunspots occur in pairs?
   A) They don't. If you see multiple sunspots in a group, however many there are, it is a coincidence. The spots are unrelated.
   B) Because whenever a sunspot forms, it automatically fragments, or splits in two.
   C) Because they are the result of the convection process: one spot is hotter (rising), the other is cooler (sinking).
   D) Sunspot pairs correspond to the N and S poles of a magnet, because they are the result of magnetic field lines breaking through the surface of the photosphere.

5. What can you conclude about the absence of sunspot data prior to 1610?
   A) Sunspots did not exist before 1610.
   B) An enormous amount of sunspot data was compiled by the ancient Greeks, but it was lost when the library at Alexandria was accidentally burned up by Caesar in 48BCE.
   C) Until Galileo turned his telescope to the sun in about 1609, the technology required to make systematic observations over extended periods of time simply wasn't available.
   D) Sunspots were known to exist, but most cultures regarded them as evil omens, and so actively avoided observing or counting them.

6. True or false: The Maunder Minimum of the 17th century coincided with a period of unusually cold weather in the Northern Hemisphere.

7. True or false: Every solar maximum is virtually identical. The number of sunspots per day at solar maximum is 140 (plus or minus one or two).



8. The graph above illustrates sunspot counts for the second half of the 19th century. A minimum is shown in 1901. Based on the trend above, when would you expect the *next* sunspot minimum to have occurred?
   A) 1905-06
   B) 1912-13
   C) 1923-24
   D) 2000-01

9. Suppose at the solar maximum shown in 1859-60, the sun's rotational N and magnetic N poles coincided. At the next maximum in 1870,
   A) magnetic N and rotational N would still coincide.
   B) magnetic N would be aligned with rotational S.
   C) magnetic N would be aligned at the solar equator.
   D) the sun would have zero magnetic field.

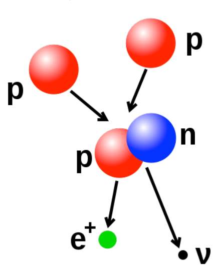
10. True or false**:** The sun's magnetic field orientation during the 1883 solar maximum was the same as during the 1859-60 solar maximum.

11. Where are we, in the year 2016, on the sunspot cycle?
   A) Sunspot activity is predicted to be approaching maximum, but actual sunspot counts for 2016 are dramatically below the prediction.
   B) Sunspot activity is predicted to be maximum in mid-2016. Actual sunspot counts are within the predicted error bars.
   C) 2016 is a midway (approaching minimum) year for sunspots. Current observations agree with the prediction.
   D) 2016 should be a year of minimal sunspot activity. However, scientists are alarmed because the actual counts are well above the predicted normal levels.

12. How is the shape of the **solar corona** related to the sunspot activity cycle?
   A) When sunspot activity is minimal, the corona appears fairly uniform and symmetric.
   B) Periods of maximum sunspot activity result in a symmetric, uniformly shaped corona.
   C) The corona is always a very symmetric, uniform shape. However, it is only visible when sunspots are very active.
   D) The corona is never symmetric or uniform; its shape is always irregular. However, when sunspot activity decreases, the coronal asymmetry increases.

13. Which is hotter, the solar photosphere or the solar corona?
   A) Photosphere. Since the corona is the outermost layer, farthest from the core, it is the coolest.
   B) Corona. The particles are moving fast enough to escape the sun's gravity. High velocity means high temperature!
   C) Neither. The photosphere, chromosphere, and corona all have the same temperature.

14. How close do a pair of protons have to get before the strong force overcomes electrostatic repulsion?
   A) About 1 parsec.
   B) About 1 AU.
   C) About 1 km.
   D) About 10^{-15}m.
   E) Trick question! There is no way for protons to overcome electrostatic repulsion!



The figure on the left illustrates the first step on the **proton-proton chain**. Two protons collide, and one becomes a neutron. To conserve both mass and energy, a **positron** and a **neutrino** are ejected as well.

15. Why is a positron (e+) emitted?
   A) Because one proton loses a tiny bit of mass and charge as it converts into a neutron.
   B) Because one proton takes a bit of mass from the other one, causing some (+) charge to be expelled.

16. What is a **deuterium** nucleus (deuteron)?
   A) An isotope of hydrogen: 1 proton + 1 neutron.
   B) An isotope of hydrogen: 1 proton + 2 neutrons.
   C) An isotope of helium: 2 protons + 1 neutron.
   D) An isotope of helium: 2 protons + 2 neutrons.

17. What is the next step of the proton-proton chain?
   A) The deuteron collides with a second deuteron. After it ejects a neutron, it is a stable He nucleus.
   B) The deuteron collides with another proton, forming a stable helium nucleus.
   C) The deuteron collides with a neutron. The neutron then turns itself into a proton, completing the chain.
   D) The deuteron collides with a proton. This is not stable He, and another collision is still necessary to form the stable He nucleus.

18. What is the final result of the proton-proton chain?
   A) After several nuclear reactions (collisions), hydrogen is fused into helium.
   B) You start with two protons, you end with two protons. Hence the name.
   C) After several nuclear reactions, two protons split to become four protons (then those four become eight, and so on).
   D) The name is strictly literal: protons bind to other protons, forming a long chain (like beads on a wire). Each "bead" added causes some energy to be released.

19. The **proper motion** of a star refers to
   A) a star's actual motion, once the parallax shift has been removed.
   B) its Doppler shift (blue or red) as the object either approaches or recedes.
   C) the shift in its apparent position due to the motion of the Earth around the sun.
   D) the wobble of a star on its rotation axis as its planets tug on it gravitationally.

20. As you watch a car drive away, you notice the tail lights
   A) getting dimmer. The lights are half as bright at 200ft as they were at 100ft away from you.
   B) getting dimmer. The lights are only 1/4 as bright at 200 ft as they were at 100 ft away from you.
   C) getting brighter. The lights are twice as bright at 200ft as they were at 100 ft.
   D) getting brighter. The lights are 4 times as bright at 200ft as they were at 100 ft.

21. The **apparent** (or visual) magnitude scale
   A) increases linearly with a star's apparent brightness: a magnitude 2 star appears twice as bright as a magnitude 1.
   B) decreases linearly with a star's apparent brightness: a magnitude 1 star appears twice as bright as a magnitude 2 star.
   C) increases exponentially with a star's apparent brightness: a magnitude 2 star appears 10 times as bright as a magnitude 1 star.
   D) decreases logarithmically as a star's apparent brightness increases: a magnitude 1 star appears 2.5 times brighter than a magnitude 2 star.

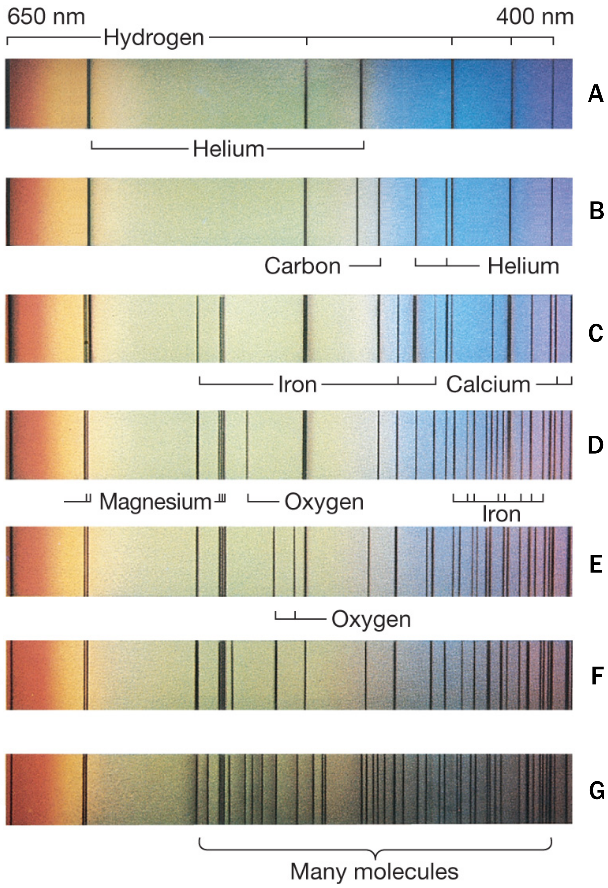
22. True or false**:** A star with a positive absolute magnitude ($M > 0$) is intrinsically brighter than a star with negative absolute magnitude ($M < 0$).

23. True or false: A star with color index $B–V = –0.19$ is hotter than a star with $B–V = +0.38$.

24. The spectral type of our sun is **G2 V**. The star Tau Ceti has a spectral type **G8.5 V**. Both are main sequence stars (luminosity class V).
   A) Both stars have the same surface temperature because they are both type G stars.
   B) Tau Ceti is hotter because it is a subtype 8.5.
   C) The sun's temperature is higher because it is a 2.
   D) Comparing the spectral types cannot tell you anything

about the temperature of either star.

Use the figure below to answer questions Questions 25–27.



25. True or false: Star B is much hotter than Star F.

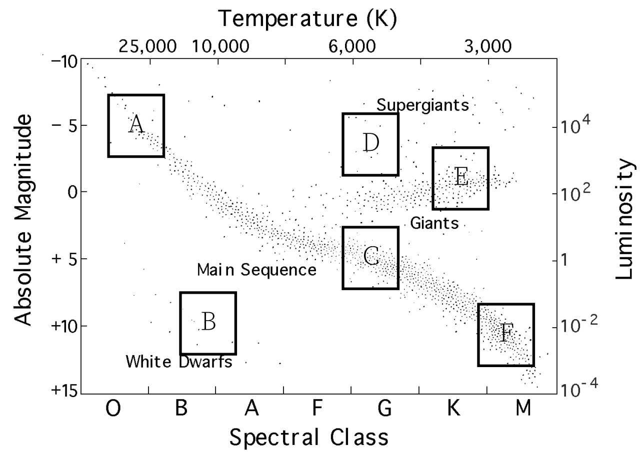
26. Which spectrum represents the **hottest** star? A

27. Which spectrum is *most likely* to represent a **sun-like** (spectral type G) star? E

28. True or false: If two stars have the same temperature, they must also have the same intrinsic luminosity.

29. Polaris has the same spectral type as the sun (G2), but its luminosity is 10,000L⊙. Its **radius** must be
    - A) (1/10,000)R⊙.
    - B) (1/100)R⊙.
    - C) (1/10)R⊙.
    - D) 1R⊙.
    - E) 100R⊙.
    - F) 10,000R⊙.

30. Place **Polaris** in the appropriate location on the H-R diagram below. Use the regions marked on the H-R Diagram below as your multiple choices. D



31. Where would our own **sun** be placed on the above H-R Diagram? Use the multiple choices on the figure. C

Use the table of star data on the front of this exam to answer the following Questions 32–37.

32. Determine which of the stars on the table is closest to the Earth, and which star is the farthest.
    - A) Closest = Procyon and farthest = Deneb.
    - B) Closest = Tau Ceti and farthest = Deneb.
    - C) Closest = Deneb and farthest = Tau Ceti.
    - D) Closest = Aldebaran and farthest = Tau Ceti.
    - E) Closest = Spica and farthest = Betelgeuse.

33. How do you *know* which star is the closest?
    - A) The star which appears the brightest is the closest.
    - B) The intrinsically brightest star is the closest.
    - C) The star with the largest parallax is the closest.
    - D) The star with the smallest parallax is the closest.

34. True or false: The star which *appears* the brightest to us is also *intrinsically* the most luminous.

35. Which of the stars is the **coolest**? That is, which star has the **lowest** surface temperature?
    - A) Aldebaran
    - B) Betelgeuse
    - C) Deneb
    - D) Procyon
    - E) Spica
    - F) Tau Ceti

36. Which of these stars are **main sequence** stars?
    - A) They are all main sequence stars!
    - B) Tau Ceti, Spica, and Procyon only.
    - C) Deneb, Aldebaran and Betelgeuse only.
    - D) Spica only.
    - E) None of these are main sequence stars.

37. Of the following main sequence stars, which will have the **shortest** lifespan?
    - A) Alpha Centauri (G2 V)
    - B) Alpha Eridani (B5 V)
    - C) Epsilon Eridani (K2 V)
    - D) Gamma Virginis (F0 V)
    - E) Phi Orionis (B0 V)
    - F) Barnard's Star (M4 V)

38. What information does the **luminosity class** of a star provide?
   A) Brightness: Higher luminosity class indicates a higher apparent magnitude, which actually means a dimmer star as viewed from Earth.
   B) Temperature: Stars with a higher luminosity class have a higher temperature.
   C) Mass: The higher the luminosity class, the larger the mass of the star.
   D) Size: Luminosity classes I through IV are giant stars, but lower number indicates larger star. Class V is main sequence.

39. **True or false:** There exist many more (cool, red) K and M type stars than (hot, blue) O and B type stars.

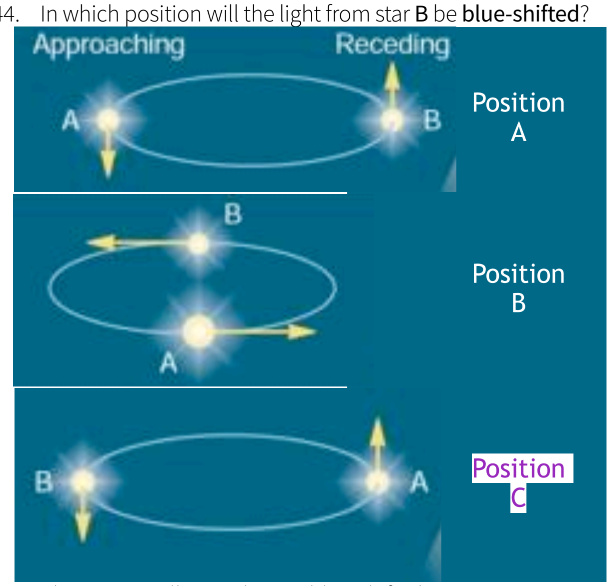
40. The position of a star on an HR diagram can tell you all of the following *except*:
   A) Temperature.
   B) Luminosity.
   C) Stellar radius.
   D) Distance from the sun.
   E) Trick question! The HR diagram can be used to ascertain all of the information above!!

41. What is the point of observing binary star systems?
   A) No point. They are just interesting to astronomers because they are different than our sun, which has no binary companion.
   B) Analyzing binary systems gives us the data we need to calculate stellar masses.
   C) Binary star systems can demonstrate the processes of stellar evolution (for example, classical novae).
   D) Both B and C are good reasons to pay attention to binary star systems.

42. True or false: Every visual binary is also an eclipsing binary.

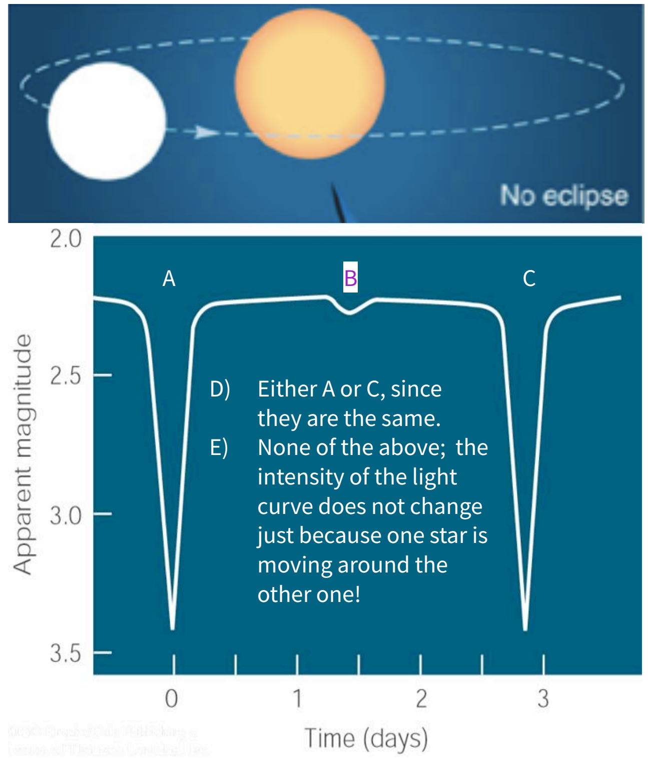
43. What is a **spectroscopic** binary?
   A) A single star which, because it has large planets, shows two separate spectra as it wobbles.
   B) A pair of stars orbiting each other which may not appear as two distinct objects. They cannot be resolved visually, but their Doppler-shifted spectra reveal the presence of two stars.
   C) Any binary star system viewed from the top down (as opposed to viewed edge-on).
   D) Any binary star system in which one star is significantly hotter and brighter than the other star.

44. In which position will the light from star **B** be **blue-shifted**?



   D) Star B will never have a blue-shifted spectrum.
   E) The spectrum of Star B will always appear blue-shifted.

45. In the figure below, the central star is the cooler star, and the slightly smaller star is a hotter star. When the hotter star passes in front of the cooler star, what happens to the light curve?



   D) Either A or C, since they are the same.
   E) None of the above; the intensity of the light curve does not change just because one star is moving around the other one!

46. In the interstellar medium, how do you distinguish between "**gas**" and "**dust**?"
   A) Singular atoms or molecules form a gas, but when molecules begin to clump together, it is considered dust.
   B) Gas is hydrogen. Anything that is not hydrogen is considered dust.
   C) Gas is transparent to all wavelengths of electromagnetic radiation. Dust is opaque to all wavelengths.
   D) Gas is found in regions of starbirth, but dust is only found in regions of old, dying stars.

47. True or false: As viewed by the Hubble Space Telescope, a star might appear cooler and redder than it actually is.

48. Describe **interstellar reddening**.
   A) Because the interstellar medium is predominantly hydrogen, the H-α line makes stars all appear red.
   B) When viewed through a cloud of interstellar gas and dust,a star will appear redder than it actually is. The blue light it emits will be scattered more by the cloud than the red light will be.
   C) A cloud of interstellar gas and dust will absorb red light and transmit blue. The interstellar cloud appears redder than it is, and the star appears bluer than it should.
   D) The gas and dust will absorb all visible frequencies, so nothing will be visible except the infrared wavelengths. This is why the clouds appear reddish when viewed with the Spitzer Space Telescope.

49. How would an astronomer know that the star she was viewing was affected by interstellar reddening?
   A) She would not be able to tell. This is why observations in the visible part of the e·m spectrum are so unreliable.
   B) The spectrum of a cooler star will always show lines not present for a hotter star. The spectral lines will always tell you about the spectral type (and thus the temperature) of a star.

50. The average density of the interstellar medium?
    - A) Trick question! Density = zero. The vacuum of interstellar space contains zero atoms or molecules.
    - B) About 1 atom per cubic centimeter.
    - C) About 10^6 atoms/cm^3.
    - D) About 10^9 atoms/cm^3.
    - E) About 10^{19} atoms/cm^3.

51. The composition of the interstellar medium?
    - A) Hydrogen. 100% pure organic hydrogen.
    - B) Helium. There is a surprising abundance of helium in interstellar gas clouds.
    - C) Water vapor. Just like clouds on Earth, interstellar clouds are made of water vapor, with traces of more complex molecules.
    - D) Interstellar clouds have stellar compositions. That is, they are 99% hydrogen and helium, with about 1% everything else.
    - E) There is no way to generalize. Every region has a completely unique composition. One cloud might be hydrogen rich, another might have no hydrogen at all. No way to tell.

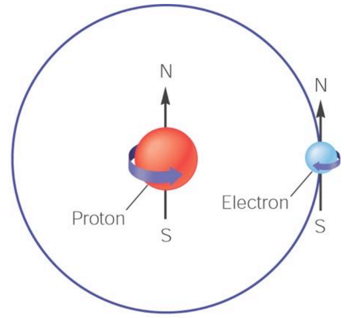
52. What color does an r**eflection nebula** typically appear?
    - A) White. A nebula is a cloud of water vapor, so it appears white or maybe grayish, just like clouds on Earth.
    - B) Black. A reflection nebula does not emit visible light, so it appears as a black patch.
    - C) Green. Because green is in the middle of the visible spectrum, it's the average wavelength. Nebulae are usually green.
    - D) Red. The reflection nebula is hot and glows red because of the strong H-α emission line.
    - E) Blue. A cool reflection nebula reflects and scatters the blue light that strikes it.

53. An **emission nebula** will typically appear
    - A) White. A nebula is a cloud of water vapor, so it appears white or maybe grayish, just like clouds on Earth.
    - B) Black. A emission nebula does not emit visible light, so it appears as a black patch.
    - C) Green. Because green is in the middle of the visible spectrum, it's the average wavelength. Nebulae are usually green.
    - D) Red. The emission nebula is hot and glows red because of the strong H-α emission line.
    - E) Blue. A cool emission nebula reflects and scatters the blue light that strikes it.

54. True or false: The Earth is located near the center of what is called the "Local Bubble," a region of unusually hot low-density gas.

55. True or false: A dark dust cloud which does not emit or reflect visible light is typically both colder and much more dense than a bright emission nebula.

56. A neutral hydrogen atom is illustrated in the figure on the right. Is the electron shown likely to spin-flip and emit a photon?



    - A) Yes. The atom is in an unstable, high-energy state, so the e^- will flip to the opposite spin.
    - B) No. The aligned magnetic fields are the stable, low energy state. The e^- has no reason to flip its spin.
    - C) You cannot say whether the electron will flip or not. It's totally random.
    - D) This is a trick question. The electron does not spin-flip. The proton in the nucleus will flip its spin.

57. When an electron executes a spin-flip transition in a hydrogen atom, how much energy is released?
    - A) It varies. Each transition will be unique, depending on how fast the electron is spinning when it flips.
    - B) This is a high-energy transition, and a high frequency X-ray photon is emitted.
    - C) The energy emitted will be in the form of a photon having a 656nm wavelength—this is red light!
    - D) Very little energy is released. The photon emitted has a 21cm wavelength, making it a radio wave.

58. In a molecular cloud, you will typically find spectral lines for molecules like ammonia (NH_3), water vapor, (H_2O) and even cyanide (HCN). What you *won't* find is a 21-cm hydrogen line. Why not?
    - A) Because there is no hydrogen in a molecular cloud. The missing line proves it!
    - B) The 21-cm line will be obscured by the other lines from all the other molecules. It's there, but it's hidden.
    - C) There's hydrogen, and it emits that 21-cm line. The other molecules, however, absorb that energy and the line disappears.
    - D) All of the hydrogen has been ionized. When the electron is stripped from the hydrogen nucleus, there cannot be a 21-cm line.
    - E) The cloud is cool enough that the atomic hydrogen has combined with other atoms (ammonia = NH_3 for example), or with itself to make hydrogen molecules. Either way, no atomic hydrogen is left to form the line.

59. True or false: A molecular cloud complex may be as large as 50pc across, and contain enough matter to make a million G2 stars like our own sun.

60. What minimum mass is required for a collapsing cloud fragment to become a true star, with hydrogen fusion at its core? The minimum mass must be approximately
    - A) $0.01M_\odot$.
    - B) $0.1M_\odot$.
    - C) $1.0M_\odot$.
    - D) $10M_\odot$.
    - E) $100M_\odot$.
    - F) $1000M_\odot$.

Double-check your answers before turning in your test paper, but **please do not click submit** until you have completed the quizzes!!!