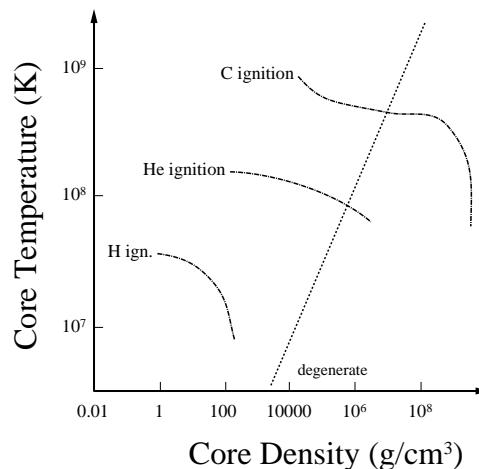
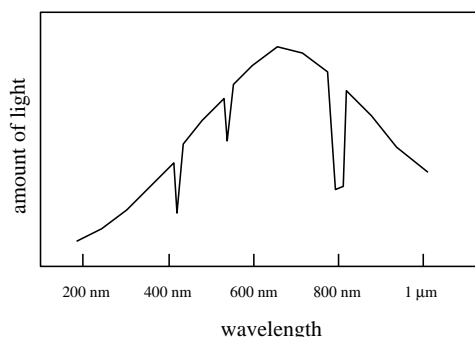


Answer TRUE or FALSE (not T or F) (2 pts each)

1. Star α and star β have the same mass, but star α has twice the radius and half the surface temperature of star β . We can conclude that these two stars have different chemical compositions.
2. Under the conditions described above, the big cool star (α) will be more luminous than the hot small star (β).
3. As a protostar the Sun was cooler and more luminous than it is today.
4. The Sun is brighter today than it was a billion years ago.
5. The Sun is population class I and luminosity class V.
6. *Planetary nebulae* are produced by young stars just starting to produce a disk that will end up as planets.
7. HII is ionized hydrogen; H₂ is molecular hydrogen; ²H is heavy hydrogen (deuterium).
8. Stars are gradually polluting the ISM (interstellar medium) with metals.
9. *Dredge up*: the onion-like layers of a star are mixed by convection.
10. A star's motion on the HR diagram results in a Doppler shift that can be detected on Earth.
11. Regulus was born before the Sun was born.
12. The Algol Paradox is resolved by mass transfer.
13. In a degenerate electron gas, the electrons can have lots of kinetic energy even at low temperature.
14. Other things being equal (e.g., same surface temperature), the more massive the white dwarf, the less luminous it will be.
15. The normal-size spin and magnetic field of a star are hugely super-sized in the collapse to a neutron star: conservation laws are at work.
16. You watch horrified as your favorite cat Tiger (encased in tidal-force proof armor) is dropped into a black hole. But you will grow old and die before you see Tiger go through the event horizon.
17. Tiger sees little to perturb him: it doesn't take much time to reach the event horizon and nothing noticeable happens as he traverses the event horizon.
18. Astronomers look for *type II supernovae* (which our book calls 'core-collapse' supernovae) in globular clusters in order to determine their distance.
19. Type Ia supernovas (which our book calls 'thermonuclear' supernovae) and novas are both thought to involve the binary companion of a white dwarf dumping material onto that white dwarf.
20. On Hubble's tuning fork, lenticular galaxies (S0) are the bridge linking spirals and ellipticals.

Give a short explanation (5 pts each)

21. Consider the following list of interstellar ‘clouds’ discussed in class: molecular clouds, HII regions, HI clouds, ‘hot vacuum’. For two of these cloud-types describe what type of light the cloud emits. That is: with what sort of light can the cloud be observed?
22. Where should you look to see new stars forming? What sort of telescope should you use? Why?
23. Describe how conditions at the core of the Sun change as the Sun evolves from main sequence to its final “death”. Plot those conditions directly on the below right diagram.



24. Consider the effects of looking at a star through a cloud of *dust*. The above left spectrum represents the light *produced* by a star and viewed without dust in the way. Draw *directly on the above diagram* what the spectrum of the star would look like if observed through a dust cloud.
25. I described several principles of stellar evolution including: (A) the virial theorem, (B) the Russell-Vogt theorem, (C) sequential thermonuclear fusion leading to nonburnable iron. Briefly define each of the above and describe its role in stellar evolution.
26. Draw a Hertzsprung-Russell diagram. Properly label axes. Show star paths (and direction) that:
 - (a) show a star increasing its temperature while keeping its luminosity constant
 - (b) show a star increasing its temperature while keeping its radius constant
27. In question 37, I ask you to report the evolution of the Sun. Describe briefly here how the evolution of stars much more massive than the Sun (say, $30 M_{\odot}$) and stars much less massive than the Sun (say, $\frac{1}{10} M_{\odot}$) differs from that of the Sun.
28. Our book asserts that “most of the carbon in your body was produced long ago inside a star”. What is the basis of such a sweeping statement? How did those atoms get out of that star and end up here on Earth? What were those atoms doing during the billions of years before they became part of your body?
29. Describe a *pulsar*. Include: how it is formed, how it is observed, and typical radius.
30. Special relativity predicts several effects for fast moving object that violate common sense ideas (which are based on ‘normal’ speeds): Lorentz contraction, time dilation, and relativity of simultaneity. Briefly define these effects.

31. Describe the evidence for “dark matter” in our Galaxy.
32. Since we can't see through our own Galaxy with visible light, e.g., to the galactic center, how is it we *can* see with visible light other galaxies which are much further away?
33. Most ways of measuring distance in astronomy are based on the distance modulus: $m - M$ (where m is the easily measured apparent magnitude and M is the absolute magnitude). When using these methods one must somehow ‘know’ the absolute magnitude of a distant object. Report two examples of objects whose absolute magnitude can be determined and report what data must be collected to make that determination.
34. Sketch E5, Sa, and SBc galaxies.
35. Other than shape, how do the above galaxies differ?

Write out a complete answer (10 pts each)

36. The open cluster NGC 6231 includes more than two dozen O and B stars, including the B1Ia star ζ^1 Sco. While ζ^1 is one of the most luminous stars in our Galaxy, at magnitude of 4.7 it is just barely visible to the unaided eye. Only 0.1° from ζ^1 , the star ζ^2 has an apparent magnitude 3.6 and spectral type K4III. Use this information (and the following statements) to answer any **five** of the below questions.
 - (a) Is ζ^1 Sco a Population I or Population II star? Explain.
 - (b) ζ^1 Sco has an apparent color redder than the F2III star β Cas. How would we know that ζ^1 Sco is B1Ia rather than having a spectral type similar to β Cas? (I.e., what data are used to determine spectral type?)
 - (c) What could cause this inappropriate red color in what should be a blue star?
 - (d) On the other hand, ζ^2 Sco has an appropriate color just a bit bluer than Aldebaran. What causes ζ^2 Sco to be appropriately colored whereas neighboring ζ^1 Sco is too red?
 - (e) Is ζ^2 Sco also a member of the open cluster NGC 6231? Explain.
 - (f) Books report that the typical absolute magnitude of a B1Ia star like ζ^1 Sco, is $M \approx -9$. Using the apparent magnitude of 4.7, we can calculate a distance modulus corresponding to about 5,500 pc. This is probably *not* a very accurate distance to ζ^1 Sco. Why? Is the actual distance likely to be more than 5,500 pc, less than 5,500 pc, or just totally indeterminate?
 - (g) Suggest a more accurate method to find the distance to ζ^1 Sco.
37. A star like the Sun is believed to go through the following stages: planetary nebula, protostar, red giant, double shell burning, He flash, main sequence, and white dwarf. Describe (in words) the characteristics of each stage. Order these stages from first to last, and locate them on an HR diagram. For two of these situations draw a cross-section of the Sun displaying the internal structure. Remember to label the axes of your HR diagram!
38. Draw a face-on view and a side view of our Galaxy. Label and show spiral arm, disk, nuclear bulge, globular cluster, open cluster, halo, population I star, population II star and the Sun's position. How far is the Sun from the center of our Galaxy? What is the thickness of our Galaxy's disk?

39. Consider the history of the discovery of the nature of our Galaxy. Give an example of each of the following:
- (a) mismeasurement leads to misunderstanding
 - (b) wrong assumptions lead to misunderstanding
 - (c) where Occam's Razor failed (i.e., where simple assumptions — assumptions of the least possible novelty — produced incorrect conclusions)
 - (d) a crucial measurement quickly settles a scientific argument
 - (e) measurement of the mundane produces far-reaching conclusions (e.g., unexpected connections)
40. The below diagram shows the winter hexagon. Eight of these dots represent stars you should know. Circle these "important" stars and label with the name and spectral type of the star.

