Except for questions 21, 22 and 32 marks/answers on these sheets are not graded.
Record your answers on your answer sheets unless the question states otherwise!

Answer *TRUE* or *FALSE* (<u>not</u> *T* or *F*) (2 pts each)

1. A star's motion on the HR diagram results in a Doppler shift that can be detected on Earth.
2. HI is the source of 21 cm (spin-flip) light.
3. According to Russell & Vogt: if 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.
4. As a *protostar* the Sun started cooler and more luminous than it is today.
5. The Sun is slightly brighter today than it was four billion years ago because it now has less hydrogen fuel than it had originally.
6. Interstellar clouds with high temperatures and densities are the most likely to collapse into stars.
7. HII is ionized hydrogen; H_2 is molecular hydrogen; ^{2}H is heavy hydrogen (deuterium).
8. Regulus was born before the Sun was born.
9. A FV star has more mass than a KV star.
10. It is impossible to slow down the high speed electrons in a degenerate electron gas except by allowing it to expand and become a normal gas.
11. Generally speaking, population II stars are older, not found in the disk, and have a lower "metal" concentration than do population I stars.
12. *Pulsars* are stars that balloon in and out at a steady and quick rate.
13. If tomorrow the Sun became a black hole, the planets would quickly be sucked into the hole.
14. Approximately speaking nothing can escape from 'inside' a black hole, but in fact Stephan Hawking calculated that black holes should be incandescent (but typically with so low a temperature that the light could not be detected).
15. Since *type II supernovae* (which our book calls 'massive star supernovae') can produce neutron stars, we should expect them to emit lots of neutrinos.
16. *Type Ia supernovas* (which our book calls 'white dwarf supernovae') and novas are both thought to involve the binary companion of a white dwarf dumping material onto that white dwarf.

Give a short explanation (5 pts each)

17. Select two of the following list of stellar properties and describe how those properties could be measured from Earth: mass, radius, luminosity, temperature.

18. The following reasoning comes to an incorrect conclusion and hence must contain a logical flaw. Explain that flaw!

    "Stars are all made of pretty much the same stuff, and each type of stuff has characteristic absorption and emission lines, so every star's spectra has much the same set of absorption and emission lines."

19. Draw a Hertzsprung-Russell diagram. Properly label axes. Show star paths (and direction) that:

    (a) show a star decreasing its temperature while keeping its luminosity constant

    (b) show a star increasing its temperature while keeping its radius constant

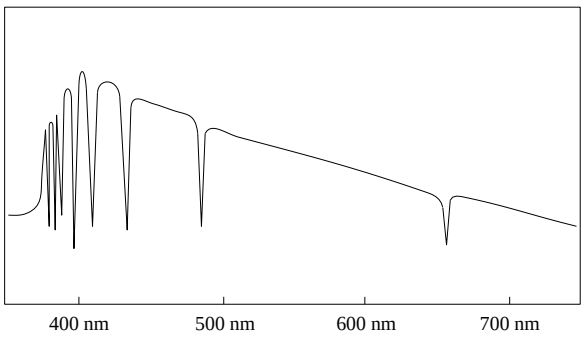
20. Consider the following list of interstellar 'clouds' discussed in class: molecular clouds, HII regions (textbook: 'ionization nebulae'), HI clouds (textbook: 'atomic clouds'), hot vacuum (textbook: 'hot bubbles'). For two of these cloud-types describe the atom-scale process that produces the light the cloud emits. That is: with what sort of light can the cloud be observed?

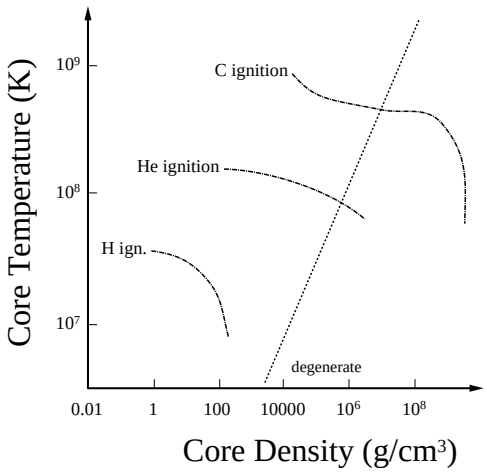
21. The below left graph displays a somewhat simplified spectra of the A7 V star Altair. All of the absorption features are produced by hydrogen gas in the atmosphere of the star.

    (a) How would the absorption features change in a A7 I star?

    (b) How would the absorption features change in a M7 V star?

    (c) How would the entire spectra change if Altair were viewed through a cloud of dust? Draw the result directly on top of the below spectra.





22. Describe (words!) 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 above right diagram.

23. You answer to the previous question should have relied on (A) the virial theorem, and (B) sequential thermonuclear fusion. *Define/explain* each of the above and explain how they apply to the diagram and your answer to the previous question.

24. In question 30, 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.

25. Our book asserts that "Without the lives and deaths of stars none of us would be here. We are truly made of 'star stuff.'" 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 'recently' (i.e., the last billion of years) before they became part of your body?

26. Describe a *neutron star*. Include: how it is formed, how it is observed, and typical radius.

27. Describe a *white dwarf*. Include: how it is formed, how it is observed, and typical radius.

28. Describe a *black hole*. Include: how it is formed, how it is observed, and typical radius.

Write out a complete answer (10 pts each)

29. Answer the following questions using the below data.

Star Name	Absolute Magnitude M_V	Apparent Magnitude m_V	Spectral Type	Luminosity Class
1. Alnilam	−6.6	1.7	B0	I
2. μ Cep	−7.0	4.1	M2	I
3. 61 Cyg B	8.4	6.7	K7	V
4. λ Ser	4.4	4.4	G0	V
5. Fomalhaut	2.0	1.2	A3	V
6. β Aqr	−5.8	4.4	G2	I
7. Canopus	−3.5	−0.7	F0	II
8. Regulus	−0.7	1.4	B7	V
9. Aldebaran	−0.5	0.9	K5	III

Which star...

(a) Which star would look the dimmest in the sky?

(b) Which star is intrinsically the dimmest?

(c) Which star is a red colored supergiant?

(d) Which star has the highest surface temperature?

(e) Which main sequence star has the lowest surface temperature?

(f) Which star is furthest away?

(g) Which star is 10 parsecs away?

(h) Which star has the largest radius?

(i) Which star has the smallest radius?

(j) Which star is most similar to the Sun?

30. A star like the Sun is believed to go through the following stages: planetary nebula, protostar, red giant, double shell burning (asymptotic giant), 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 you draw/construct. 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!

31. 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. What is the diameter of our Galaxy? What is the thickness of our Galaxy's disk?

32. The below diagram shows the winter hexagon. Eight of these dots represent stars you should know. Directly on this sheet, circle these "important" stars and label with the name and spectral type of the star.