Introductory Astronomy **NAME:**

Homework 22: The Main Sequence Life of Stars: Homeworks and solutions are posted on the course web site. Homeworks are **NOT** handed in and **NOT** marked. But many homework problems (∼ 50–70 %) will turn up on tests.

Answer Table

Name:

	a	b	c	d	e		a	b	c	d	e
1.	O	O	O	O	O	37.	O	O	O	O	O
2.	O	O	O	O	O	38.	O	O	O	O	O
3.	O	O	O	O	O	39.	O	O	O	O	O
4.	O	O	O	O	O	40.	O	O	O	O	O
5.	O	O	O	O	O	41.	O	O	O	O	O
6.	O	O	O	O	O	42.	O	O	O	O	O
7.	O	O	O	O	O	43.	O	O	O	O	O
8.	O	O	O	O	O	44.	O	O	O	O	O
9.	O	O	O	O	O	45.	O	O	O	O	O
10.	O	O	O	O	O	46.	O	O	O	O	O
11.	O	O	O	O	O	47.	O	O	O	O	O
12.	O	O	O	O	O	48.	O	O	O	O	O
13.	O	O	O	O	O	49.	O	O	O	O	O
14.	O	O	O	O	O	50.	O	O	O	O	O
15.	O	O	O	O	O	51.	O	O	O	O	O
16.	O	O	O	O	O	52.	O	O	O	O	O
17.	O	O	O	O	O	53.	O	O	O	O	O
18.	O	O	O	O	O	54.	O	O	O	O	O
19.	O	O	O	O	O	55.	O	O	O	O	O
20.	O	O	O	O	O	56.	O	O	O	O	O
21.	O	O	O	O	O	57.	O	O	O	O	O
22.	O	O	O	O	O	58.	O	O	O	O	O
23.	O	O	O	O	O	59.	O	O	O	O	O
24.	O	O	O	O	O	60.	O	O	O	O	O
25.	O	O	O	O	O	61.	O	O	O	O	O
26.	O	O	O	O	O	62.	O	O	O	O	O
27.	O	O	O	O	O	63.	O	O	O	O	O
28.	O	O	O	O	O	64.	O	O	O	O	O
29.	O	O	O	O	O	65.	O	O	O	O	O
30.	O	O	O	O	O	66.	O	O	O	O	O
31.	O	O	O	O	O	67.	O	O	O	O	O
32.	O	O	O	O	O	68.	O	O	O	O	O
33.	O	O	O	O	O	69.	O	O	O	O	O
34.	O	O	O	O	O	70.	O	O	O	O	O
35.	O	O	O	O	O	71.	O	O	O	O	O
36.	O	O	O	O	O	72.	O	O	O	O	O

1. Did you complete reading the intro astro web lecture before the **SECOND DAY** on which the lecture was lectured on in class?

   a) YYYessss! b) Jawohl! c) Da! d) Sí, sí. e) OMG no!

2. A star lying on the main sequence on a Hertzsprung-Russell diagram is a:

   a) main-sequence star. b) pre-main-sequence star. c) post-main-sequence star. d) white dwarf. e) red giant.

3. "Let's play *Jeopardy*! For \$100, the answer is: It is a star that as observed over relatively short times scales (e.g., all of human history) is burning hydrogen to helium in its core at a constant rate and is in hydrostatic equilibrium."

   What is a/an ____________, Alex?

   a) dense core b) protostar c) pre-main-sequence star d) H II region e) main-sequence star

4. For a main sequence star, the energy radiated away as electromagnetic radiation is almost exactly compensated by:

   a) gravitational energy converted to heat energy during rapid collapse. b) neutrinos from space being absorbed by the star. c) energy produced by nuclear burning on the surface. d) energy produced by nuclear burning in the deep interior. e) nothing at all.

5. Atomic nuclei are made up of:

   a) protons and neutrons. b) protons and electrons. c) positrons and electrons. d) positrons and neutrals. e) ponytrons and nuggets.

6. The nucleus is occupies ____________ of the volume of an atom and has ____________ of the atomic mass.

   a) a small part; none b) a small part; almost all c) most; almost all d) most; none e) most; half

7. Nuclei with the same number of protons, but different number of neutrons are ____________ of each other.

   a) isochrones b) isobars c) isotopes d) isodopes e) Isoldes

8. "Let's play *Jeopardy*! For \$100, the answer is: These isotopes of hydrogen have 1 and 2 neutrons, respectively."

   What are ____________, Alex?

   a) uranium-235 ($^{235}_{92}$U) and uranium-238 ($^{238}_{92}$U) b) helium-3 ($^{3}_{2}$He) and helium-4 ($^{4}_{2}$He) c) the deuteronomy (D or $^{2}_{1}$H) and trident (T or $^{3}_{1}$H) d) the deuteron (D or $^{2}_{1}$H) and triton (T or $^{3}_{1}$H) e) carbon ($^{12}_{6}$C) and oxygen ($^{16}_{8}$O)

9. Nuclei are bound together by:

   a) gravity. b) the strong nuclear force. c) the electromagnetic force. d) the centrifugal force. e) the weak nuclear force.

10. Nuclear fusion is the ____________ bonding of nuclei to form ____________ nuclei.

    a) chemical; larger b) nuclear; larger c) nuclear; smaller d) chemical; smaller e) gravitational; smaller

11. In stellar hydrogen fusion to helium, the rest mass energy of the products is ________ less than that of the reactants. The missing rest mass energy went mostly into ____________.

    a) 70 %; heat energy b) 170 %; magnetic field energy c) 0.7 %; heat energy d) 70 %; magnetic field energy e) 0 %; chemical binding energy

12. 1 kg of matter is equivalent to about how much energy? Recall that the speed of light is 3.00×10^8 m/s.

    a) 8×10^{16} J. b) 9×10^{16} J. c) 9×10^8 J. d) 3×10^8 J. e) 2×10^8 J.

13. The energy emitted as electromagnetic energy from main sequence stars is supplied by the:

    a) nuclear burning of helium to hydrogen. b) nuclear burning of hydrogen to helium. c) nuclear burning of hydrogen to carbon. d) nuclear burning of helium to carbon. e) chemical burning of hydrogen to carbon.

14. Thermonuclear reactions happen only in a star's core (which for the Sun is the region within about 0.25 solar radii of the Sun's center) because only there is it ____________ enough.

    a) cold and dilute b) hot and dense c) hot and dilute d) bland and fragile e) dirty and smudgy

15. Why don't thermonuclear reactions happen on the surface of main sequence stars?

    a) Not hot and not dense enough. b) Too hot and too dense. c) Too green. d) Too bad. e) Too late.

16. In addition to observations of a star and physics theory, in order to understand the star in detail one needs:

    a) a few calculations on a scrap of paper. b) detailed computer modeling. c) experiments on Sun-size gas balls. d) nothing else at all. e) luck.

17. "Let's play *Jeopardy*! For $100, the answer is: This is a set of calculated distributions of temperature, density, luminosity, and other physical quantities for a star."

    What is ____________, Alex?

    a) the star mass b) the star itself c) a model of the star d) the star luminosity e) the astronomical unit

18. In a main sequence star (e.g., the Sun) temperature, density, and pressure:

    a) vary strongly from center to surface (i.e., photosphere).
    b) are constant throughout the star.
    c) are never higher than about 6000 K, 2×10^{-7} g/cm^3, and 0.8 Earth atmospheres, respectively.
    d) are all equal to 6000 in MKS units.
    e) are completely unknown.

19. Hydrostatic equilibrium means that:

    a) pressure and other forces in a fluid are **UNBALANCED**, but the fluid is exhibiting a **SMOOTH FLOW** (at least in the reference frame of the fluid center of mass).
    b) pressure and other forces in a fluid are **UNBALANCED** and the fluid is exhibiting a **TURBULENT FLOW** (at least in the reference frame of the fluid center of mass).
    c) pressure and other forces in a fluid are **BALANCED** and there is **NO FLUID MOTION** (at least in the reference frame of the fluid center of mass).
    d) the temperature is a constant throughout a fluid.
    e) the temperature is not a constant throughout a fluid.

20. "Let's play *Jeopardy*! For $100, the answer is: It is an everyday example of hydrostatic equilibrium."

    What is ____________, Alex?

    a) a boat's wake b) stirring coffee c) a river d) a waterfall e) water at rest in a cup

21. Main sequence stars of low mass are mainly supported against collapse ($\gtrsim 90\,\%$ for $M \lesssim 8M_\odot$) by:

    a) the pressure of liquid water. b) the ideal gas pressure of ions and electrons. c) the gravitational force. d) angular momentum. e) the solar wind.

22. An everyday example of heat transfer by radiative transport (or radiative transfer) is

    a) boiling water in a pan. b) a spoon in boiling water growing warm. c) sunlight warming. d) a refrigerator cooling. e) a dog barking.

23. In convection between a lower hot layer and an upper cold layer (with downward being the direction of gravity):

a) hot blobs rise and cold blobs rise too. b) hot blobs rise and cold blobs sink. c) hot and cold blobs both sink. d) hot and cold blobs don't form. e) hot and cold blobs madly try to consume the universe.

24. A common reason why some astrophysical systems are described as poorly understood is that these systems involve three-dimensional hydrodynamic effects (e.g., convection).

   a) Three-dimensional hydrodynamics cannot be **ACCURATELY COMPUTATIONALLY TREATED** at all.
   b) Three-dimensional hydrodynamics cannot be **TREATED EVEN QUALITATIVELY**.
   c) Three-dimensional hydrodynamics can **ALWAYS** be understood qualitatively and this allows us to **ALWAYS** predict three-dimensional hydrodynamical phenomena, just not their magnitude. Accurate computations of three-dimensional hydrodynamic effects, however, are only possible in some cases. For example, when **electromagnetic effects** are present, they actually simplify three-dimensional hydrodynamic effects and allow accurate computations in all cases.
   d) Three-dimensional hydrodynamics can **OFTEN** be understood qualitatively and this **SOMETIMES** allows us to predict three-dimensional hydrodynamical phenomena. Accurate computations of three-dimensional hydrodynamic effects are also possible in some cases.
   e) Three-dimensional hydrodynamics can **OFTEN** be understood qualitatively and this **SOMETIMES** allows us to predict three-dimensional hydrodynamical phenomena. Accurate computations of three-dimensional hydrodynamic effects are also possible in some cases. For example, when **ELECTROMAGNETIC EFFECTS** are present, they actually simplify three-dimensional hydrodynamic effects and allow accurate computations in all cases. Maybe someday all three-dimensional hydrodynamic effects will be accurately calculable.

25. During a star's **MAIN SEQUENCE LIFE**, the star is relatively unchanging. But, of course, it is actually changing slowly on the road to its demise. The key change is that:

   a) carbon dioxide (CO_2) is being expelled by the star's wind.
   b) molecular nitrogen (N_2) is being expelled by the star's wind.
   c) hydrogen fuel is being exhausted in its core.
   d) hydrogen fuel is being exhausted on its surface.
   e) helium fuel is being exhausted in its core.

26. Most nuclear-burning stars are main sequence stars. The reason for this is that the main sequence phase of the nuclear-burning life of star of any mass is the:

   a) shortest phase. b) most popular phase. c) wettest phase. d) longest phase. e) darndest phase.

27. As a **MAIN SEQUENCE STAR** ages, its luminosity (i.e., total energy output):

   a) decreases. b) increases. c) oscillates wildly. d) becomes tangential. e) incinerates.

28. At the time the Sun first became a main sequence star, its luminosity was probably ____________ than at present.

   a) 30 % greater b) 100 % greater c) 50 times greater d) 30 % lower e) 100 % lower

29. These main sequence stars have masses in the range 0.08–0.4 $M_\odot$. They have the lowest temperatures and densities in their cores of all main sequence stars and subsequently burn hydrogen to helium most slowly. Convection occurs throughout these stars and eventually they will be converted entirely into helium. They will never burn any other nuclear fuel and eventually must become helium white dwarfs. Their main sequence lifetimes are predicted by models to be hundreds of billions of years. According to our current cosmological theory the age of the universe is only about 14 billion years. Thus, none of these stars has ever left the main sequence. These stars are called:

   a) brown dwarfs. b) red dwarfs. c) white dwarfs. d) red giants. e) O stars.

30. Red dwarf stars are convective:

   a) in no region. b) only above the photopshere. c) from center to photosphere. d) only in the nuclear burning core. e) occasionally.

31. Because red dwarf stars are convective throughout (i.e., from center to photosphere), they will

a) burn helium to hydrogen only in their cores. b) never burn hydrogen at all. c) eventually burn almost all their hydrogen to helium. d) never burn either hydrogen or helium. e) burn carbon before hydrogen.

32. An object that forms in a star formation region with less than about $0.08\,M_{\odot}$, but more than about 13 Jupiter masses (according to one school of thought), and which never burns ordinary hydrogen is called a:

    a) white dwarf. b) brown dwarf. c) red dwarf. d) red giant. e) green giant.

33. Brown dwarfs are:

    a) not main sequence stars ever. b) unarguably main sequence stars. c) main sequence stars at three different times. d) sometimes main sequence stars. e) the same things as red giants.