**Star Stuff**

17.1 Multiple-Choice Questions

1) What do astronomers mean when they say that we are all "star stuff"?

A) that life would be impossible without energy from the Sun

B) that Earth formed at the same time as the Sun

C) that the carbon, oxygen, and many elements essential to life were created by nucleosynthesis in stellar cores

D) that the Sun formed from the interstellar medium: the "stuff" between the stars

E) that the Universe contains billions of stars

Answer: C

2) Which two energy sources can help a star maintain its internal thermal pressure?

A) nuclear fusion and gravitational contraction

B) nuclear fission and gravitational contraction

C) nuclear fusion and nuclear fission

D) chemical reactions and gravitational contraction

E) nuclear fusion and chemical reactions

Answer: A

3) What type of star is our Sun?

A) low-mass star

B) intermediate-mass star

C) high-mass star

Answer: A

4) What is the range of star masses for high-mass stars?

A) between 500 and about 1,000 solar masses

B) between 200 and about 500 solar masses

C) between 8 and about 100 solar masses

D) between 2 and about 10 solar masses

E) between 2 and about 5 solar masses

Answer: C

5) What can we learn about a star from a *life track* on an H-R diagram?

A) how long ago it was born

B) when it will die

C) where it is located

D) what surface temperature and luminosity it will have at each stage of its life

E) all of the above

Answer: D

6) Which of the following statements about *degeneracy pressure* is *not* true?

A) Degeneracy pressure varies with the temperature of the star.

B) Degeneracy pressure can halt gravitational contraction of a star even when no fusion is occurring in the core.

C) Degeneracy pressure keeps any protostar less than 0.08 solar mass from becoming a true, hydrogen-fusing star.

D) Degeneracy pressure arises out of the ideas of quantum mechanics.

E) Degeneracy pressure supports white dwarfs against gravity.

Answer: A

7) All of the following are involved in carrying energy outward from a star's core *except*

A) convection.

B) radiative diffusion.

C) conduction.

D) neutrinos.

Answer: C

8) Which stars have convective cores?

A) low-mass stars

B) intermediate-mass stars

C) high-mass stars

D) all of the above

E) none of the above

Answer: C

9) Which of the following spectral types is more likely to be a *flare* star?

A) KIII

B) MV

C) GV

D) I

E) BII

Answer: B

10) Which of the following properties make flare stars so active?

A) fast rotation rates

B) deep convection zones

C) convecting cores

D) strong stellar winds

E) both A and B

Answer: E

11) What happens when a star exhausts its core hydrogen supply?

A) Its core contracts, but its outer layers expand and the star becomes bigger and brighter.

B) It contracts, becoming smaller and dimmer.

C) It contracts, becoming hotter and brighter.

D) It expands, becoming bigger but dimmer.

E) Its core contracts, but its outer layers expand and the star becomes bigger but cooler and therefore remains at the same brightness.

Answer: A

12) What is happening inside a star while it expands into a subgiant?

A) It is fusing hydrogen into helium in the core.

B) It is fusing hydrogen into helium in a shell outside the core.

C) It is fusing helium into carbon in the core.

D) It is fusing helium into carbon in a shell outside the core.

E) It is not fusing any element; it is contracting and heating up.

Answer: B

13) Compared to the star it evolved from, a red giant is

A) hotter and brighter.

B) hotter and dimmer.

C) cooler and brighter.

D) cooler and dimmer.

E) the same temperature and brightness.

Answer: C

14) At approximately what temperature can helium fusion occur?

A) 100,000 K

B) 1 million K

C) a few million K

D) 100 million K

E) 100 billion K

Answer: D

15) Why does a star grow larger after it exhausts its core hydrogen?

A) The outer layers of the star are no longer gravitationally attracted to the core.

B) Hydrogen fusion in a shell outside the core generates enough thermal pressure to push the upper layers outward.

C) Helium fusion in the core generates enough thermal pressure to push the upper layers outward.

D) Helium fusion in a shell outside the core generates enough thermal pressure to push the upper layers outward.

E) The internal radiation generated by the hydrogen fusion in the core has heated the outer layers enough that they can expand after the star is no longer fusing hydrogen.

Answer: B

16) How many helium nuclei fuse together when making carbon?

A) 2

B) 3

C) 4

D) varies depending on the reaction

E) none of the above

Answer: B

17) The helium fusion process results in the production of

A) hydrogen.

B) oxygen.

C) carbon.

D) nitrogen.

E) iron.

Answer: C

18) What happens after a *helium flash*?

A) The core quickly heats up and expands.

B) The star breaks apart in a violent explosion.

C) The core suddenly contracts.

D) The core stops fusing helium.

E) The star starts to fuse helium in a shell outside the core.

Answer: A

19) What is a *carbon star*?

A) a red giant star whose atmosphere becomes carbon-rich through convection from the core

B) a star that fuses carbon in its core

C) another name for a white dwarf, a remnant of a star made mainly of carbon

D) a star that produces carbon by fusion in its atmosphere

E) a star that is made at least 50 percent of carbon

Answer: A

20) What is a planetary nebula?

A) a disk of gas surrounding a protostar that may form into planets

B) what is left of the planets around a star after a low-mass star has ended its life

C) the expanding shell of gas that is no longer gravitationally held to the remnant of a low-mass star

D) the molecular cloud from which protostars form

E) the expanding shell of gas that is left when a white dwarf explodes as a supernova

Answer: C

21) What happens to the core of a star after a planetary nebula occurs?

A) It contracts from a protostar to a main-sequence star.

B) It breaks apart in a violent explosion.

C) It becomes a white dwarf.

D) It becomes a neutron star.

E) none of the above

Answer: C

22) Which of the following sequences correctly describes the stages of life for a low-mass star?

A) red giant, protostar, main-sequence, white dwarf

B) white dwarf, main-sequence, red giant, protostar

C) protostar, red giant, main-sequence, white dwarf

D) protostar, main-sequence, white dwarf, red giant

E) protostar, main-sequence, red giant, white dwarf

Answer: E

23) Compared to the star it evolved from, a white dwarf is

A) hotter and brighter.

B) hotter and dimmer.

C) cooler and brighter.

D) cooler and dimmer.

E) the same temperature and brightness.

Answer: B

24) Most interstellar dust grains are produced in

A) the Big Bang.

B) the interstellar medium.

C) the atmospheres of red giant stars.

D) supernova explosions.

E) the solar nebula.

Answer: C

*The following questions refer to the H-R diagram below that shows the life track of a 1-solar-mass star, with various stages labeled with Roman numerals.*



25) During which stage is the star's energy supplied by gravitational contraction?

A) ii

B) iii

C) v

D) vi

E) viii

Answer: A

26) During which stage does the star have an inert (nonburning) helium core?

A) iii

B) iv

C) vi

D) vii

E) viii

Answer: B

27) During which stage does the star have an inert (nonburning) carbon core?

A) ii

B) iii

C) iv

D) vi

E) viii

Answer: E

28) Which stage lasts the longest?

A) i

B) iii

C) iv

D) vi

E) viii

Answer: B

29) What will happen to the star after stage viii?

A) It will explode in a supernova.

B) It will begin burning carbon in its core.

C) It will eject a planetary nebula.

D) It will collapse to make a neutron star.

E) It will gain mass until it collapses under its own weight.

Answer: C

30) In the end, the remaining core of this star will be left behind as

A) a white dwarf made primarily of carbon and oxygen.

B) a white dwarf made primarily of silicon and iron.

C) a neutron star.

D) a black hole.

E) a supernova.

Answer: A

*The following questions refer to the sketch below of an H-R diagram for a star cluster.*



31) Based on its main-sequence turnoff point, the age of this cluster is

A) less than 1 billion years.

B) about 1 billion years.

C) about 2 billion years.

D) about 10 billion years.

E) more than 15 billion years.

Answer: D

32) Which statement about this cluster is *not* true?

A) It is likely to be located in the halo of the galaxy.

B) It contains some stars that are burning helium in their cores.

C) It is the type of cluster known as an open cluster of stars.

D) It probably contains no young stars at all.

E) It is likely to be spherical in shape.

Answer: C

33) Consider the star to which the arrow points. How is it currently generating energy?

A) by gravitational contraction

B) by hydrogen shell burning around an inert helium core

C) by core hydrogen fusion

D) by core helium fusion combined with hydrogen shell burning

E) by both hydrogen and helium shell burning around an inert carbon core

Answer: B

34) Consider the star to which the arrow points. Which of the following statements about this star is *not* true?

A) It is significantly less massive than the Sun.

B) It is larger in radius than the Sun.

C) It is brighter than the Sun.

D) Its surface temperature is lower than the Sun's.

E) Its core temperature is higher than the Sun's.

Answer: A

35) What is the *CNO cycle*?

A) the process by which helium is fused into carbon, nitrogen, and oxygen

B) the process by which carbon is fused into nitrogen and oxygen

C) a type of hydrogen fusion that uses carbon, nitrogen, and oxygen atoms as catalysts

D) the period of a massive star's life when carbon, nitrogen, and oxygen are fusing in different shells outside the core

E) the period of a low-mass star's life when it can no longer fuse carbon, nitrogen, and oxygen in its core

Answer: C

36) Which element has the lowest mass per nuclear particle and therefore cannot release energy by either fusion or fission?

A) hydrogen

B) oxygen

C) silicon

D) iron

E) uranium

Answer: D

37) What happens when the gravity of a massive star is able to overcome *neutron* degeneracy pressure?

A) The core contracts and becomes a white dwarf.

B) The core contracts and becomes a ball of neutrons.

C) The core contracts and becomes a black hole.

D) The star explodes violently, leaving nothing behind.

E) Gravity is not able to overcome neutron degeneracy pressure.

Answer: C

38) What types of stars end their lives with supernovae?

A) all stars that are red in color

B) all stars that are yellow in color

C) stars that are at least several times the mass of the Sun

D) stars that are similar in mass to the Sun

E) stars that have reached an age of 10 billion years

Answer: C

39) Which of the following statements about stages of nuclear burning (i.e., first-stage hydrogen burning, second-stage helium burning, etc.) in a massive star is *not* true?

A) Each successive stage of fusion requires higher temperatures than the previous stages.

B) As each stage ends, the core shrinks further.

C) Each successive stage creates an element with a higher atomic weight.

D) Each successive stage lasts for approximately the same amount of time.

Answer: D

40) Suppose the star Betelgeuse (the upper left shoulder of Orion) were to become a supernova tomorrow (as seen here on Earth). What would it look like to the naked eye?

A) Because the supernova event destroys the star, Betelgeuse would suddenly disappear from view.

B) We'd see a cloud of gas expanding away from the position where Betelgeuse used to be. Over a period of a few weeks, this cloud would fill our entire sky.

C) Betelgeuse would remain a dot of light but would suddenly become so bright that, for a few weeks, we'd be able to see this dot in the daytime.

D) Betelgeuse would suddenly appear to grow larger in size, soon reaching the size of the full moon. It would also be about as bright as the full moon.

Answer: C

41) Which event marks the beginning of a supernova?

A) the onset of helium burning after a helium flash in a star with mass comparable to that of the Sun

B) the sudden outpouring of X rays from a newly formed accretion disk

C) the sudden collapse of an iron core into a compact ball of neutrons

D) the beginning of neon burning in an extremely massive star

E) the expansion of a low-mass star into a red giant

Answer: C

42) After a supernova event, what is left behind?

A) always a white dwarf

B) always a neutron star

C) always a black hole

D) either a white dwarf or a neutron star

E) either a neutron star or a black hole

Answer: E

43) Why is Supernova 1987A particularly important to astronomers?

A) It occurred only a few dozen light-years from Earth.

B) It provided the first evidence that supernovae really occur.

C) It provided the first evidence that neutron stars really exist.

D) It was the first supernova detected in nearly 400 years.

E) It was the nearest supernova detected in nearly 400 years.

Answer: E

44) You discover a binary star system in which one member is a 15*M*Sun main-sequence star and the other star is a 10*M*Sun giant. Why should you be surprised, at least at first?

A) It doesn't make sense to find a giant in a binary star system.

B) The odds of ever finding two such massive stars in the same binary system are so small as to make it inconceivable that such a system could be discovered.

C) The two stars in a binary system should both be at the same point in stellar evolution; that is, they should either both be main-sequence stars or both be giants.

D) The two stars should be the same age, so the more massive one should have become a giant first.

E) A star with a mass of 15*M*Sun is too big to be a main-sequence star.

Answer: D

45) You discover a binary star system in which one member is a15*M*Sun main-sequence star and the other star is a 10*M*Sun giant. How do we believe that a star system such as this might have come to exist?

A) The giant must once have been the more massive star but transferred some of its mass to its companion.

B) Despite the low odds of finding a system with two such massive stars, there is nothing surprising about the fact that such systems exist.

C) The two stars probably were once separate but became a binary when a close encounter allowed their mutual gravity to pull them together.

D) The main-sequence star probably is a pulsating variable star and therefore appears to be less massive than it really is.

E) Although both stars probably formed from the same clump of gas, the more massive one must have had its birth slowed so that it became a main-sequence star millions of years later than its less massive companion.

Answer: A

46) Why do scientists think that our solar system must have formed sometime after nearby supernovae explosions?

A) Existence of heavy elements

B) Solar temperature too low

C) Our Sun is a G-type star

D) They don't—scientists believe our Sun is among the first generation of stars.

Answer: A

17.2 True/False Questions

1) Photographs of many young stars show long jets of material apparently being ejected from their poles.

Answer: TRUE

2) Although some photographs show what looks like jets of material near many young stars, we now know that these "jets" actually represent gas from the surrounding nebula that is falling onto the stars.

Answer: FALSE

3) In any star cluster, stars with lower masses greatly outnumber those with higher masses.

Answer: TRUE

4) There is no limit to the mass with which a star can be born.

Answer: FALSE

5) Stars with high masses live longer than stars with lower masses.

Answer: FALSE

6) Stars of lower mass have deeper convection zones outside their cores than stars of higher mass.

Answer: TRUE

7) Convection never occurs in the core of any type of star.

Answer: FALSE

8) The helium fusion process works by fusing two helium nuclei into one beryllium nucleus.

Answer: FALSE

9) Our Sun will end its life in a planetary nebula and become a white dwarf.

Answer: TRUE

10) The most massive stars generate energy at the end of their lives by fusing iron in their cores.

Answer: FALSE

11) The heaviest element produced by stars or in supernovae is silicon.

Answer: FALSE

12) All stars that become supernovae will leave behind a neutron star.

Answer: FALSE

17.3 Short Answer Questions

*Choose from the list below for the following questions. You may use a choice more than once.*

 A. H fusion by the proton-proton chain

 B. H fusion by the CNO cycle

 C. helium fusion

 D. matter-antimatter annihilation

 E. gravitational contraction

1) Which method of energy generation is used by the Sun today?

Answer: A

2) Which one provided the energy that made the Sun hot in the first place?

Answer: E

3) Which method of energy generation provides the source of energy for a *protostar*?

Answer: E

4) Which process leads to the *production* of carbon?

Answer: C

5) When a 1-solar-mass star stabilizes as a giant for about a billion years, which method of energy generation occurs in its central core?

Answer: C

6) Which one is used by a *main-sequence* star of spectral type B2?

Answer: B

7) Which method of energy generation provides the source of energy for a 10*M*Sun main-sequence star?

Answer: B

8) Do you think it is possible that a 10-solar-mass main-sequence star could harbor an advanced civilization? Explain your reasoning.

Answer: A 10-solar-mass star has a very short lifetime. It also produces copious amounts of ultraviolet radiation, which may discourage living organisms.

9) Do you think it is possible that a flare star could harbor an advanced civilization? Explain your reasoning.

Answer: A flare star has violent flare activity that might disrupt the upper atmosphere of a planet and send energetic particles and X rays flying through living organisms–not very pleasant.

10) Do you think it is possible that a carbon star could harbor an advanced civilization? Explain your reasoning.

Answer: A carbon star is a very old low-mass star, after it has passed through the red giant phase. Earth may survive the red giant phase of the Sun, as planets in similar systems have, but. the cool red radiation may make processes such as photosynthesis difficult. Maybe an advanced civilization could have developed around this star, but it would have had to make special arrangements to survive the red giant phase of its mother star.

11) Do you think it is possible that a 1.5-solar-mass red giant could harbor an advanced civilization? Explain your reasoning.

Answer: A 1.5-solar-mass red giant is a temporary stage of life for a low-mass star. If an advanced civilization had already developed around this star, which is possible, then it may have had the resources to respond to its expanding, reddened sun.

12) Do you think it is possible that a 1-solar-mass horizontal branch star could harbor an advanced civilization? Explain your reasoning.

Answer: A 1-solar-mass horizontal branch star is a late-stage low-mass star, burning helium. Life had time to develop, but it would have had to be very clever, with natural resources and probably a lot of cooperation to persist.

13) Do you think it is possible that a red supergiant could harbor an advanced civilization? Explain your reasoning.

Answer: A red supergiant is a late-stage high-mass star in the advanced state of nuclear burning, that is, burning elements heavier than helium in its core. Its envelope is gigantic. Its age at this point is rather young since massive stars live short lives. With our assumptions above, an advanced civilization probably does not have enough time to develop.

14) Lithium, beryllium, and boron are elements with atomic number 3, 4, and 5, respectively. Even though they are three of the five simplest elements, why are they rare compared to many heavier elements?

Answer: Helium fuses into carbon by combining three helium nuclei (atomic number 2) into one carbon nucleus (atomic number 6), therefore bypassing the elements lithium, beryllium, and boron, with atomic numbers 3 through 5. Therefore, fusion processes in the cores of stars do not form these three elements. (Beyond the scope of this book: Trace amounts of lithium and perhaps beryllium and boron formed in the Big Bang. Most of the beryllium and boron may have formed via cosmic-ray collisions with heavier elements. The exact origin of these elements is still a topic of astronomical research. These three elements are also rather fragile and tend to be destroyed in the cores of stars rather than being created there.)

15) What are the three types of pressure that can push against the inward force of gravity? Explain what causes each pressure and where it would be likely to occur.

Answer:

(1) Thermal pressure occurs when the particles inside a star are heated enough so that their random motions cause an outward pressure. The two energy sources of internal thermal pressure are gravitational contraction, found in protostars and when a star has used up a fusionable material in its core, and nuclear fusion, which can occur in the core or in a shell of a star.

(2) Degeneracy pressure arises from the idea of quantum mechanics that two electrons (or neutrons) cannot occupy the same state. Degeneracy pressure occurs in the cores of low-mass stars before a helium flash, maintains equilibrium in white dwarfs and neutron stars, and may be present immediately before a supernova event.

(3) Radiation pressure exists only in massive stars where fusion rates are so high that photons transfer momentum to the surrounding gas and apply a third kind of pressure.

16) Briefly summarize the stages of life for a low-mass star.

Answer: The protostar assembles from the molecular clouds, heats up from gravitational contraction, and begins hydrogen fusion in the core. The star settles onto the main sequence, where it will fuse hydrogen in its core for 10 billion years. When the core hydrogen is used up, the core contracts until it is degenerate, hydrogen fusion continues in a shell outside the core, and the outer layers expand and cool the star becomes a red giant. Helium fusion begins in the core, but since the core is degenerate a helium flash takes place and rapidly spreads throughout the core. Helium fusion stabilizes, and the star moves left on the H-R diagram. Core helium is used up and helium begins fusing in a shell outside the core, with hydrogen still fusing in a shell above it. The outer layers expand, and the star again becomes a red giant.

 The star undergoes thermal pulses and loses its outer layers through a stellar wind. The core shrinks and heats up but is not able to fuse any more elements. The star becomes a planetary nebula as heat from the core blows away and heats up the gas left over from the red giant phase. Only the naked degenerate core is left, a white dwarf.

17) Briefly summarize the stages of life for a high-mass star.

Answer: The first stages are similar to those of a low-mass star, except that they happen over much shorter time periods. While on the main sequence, the star fuses hydrogen by the CNO cycle and remains at this stage only for several million years. In addition to helium fusion, high-mass stars also undergo alpha-capture, which creates heavier elements by fusing a helium nucleus with an existing atom. After helium is used up in the core, the core contracts while helium and hydrogen fusion continue in outer shells. The core contracts until carbon ignition occurs, and the star moves left again on the H-R diagram while carbon fusion occurs in the core. The process continues for stars of still higher mass, zigzagging across the H-R diagram as heavier elements are fused in the core and used up as fuel. Each fusion stage requires less time until iron is finally produced in the core. Iron cannot be fused to produce energy, so the core collapses and pressures increase so that electrons and protons are converted to neutrons. A high quantity of neutrinos is released, which may help force the outer layers violently outward in an explosion called a supernova. Elements heavier than iron are created, the outer layers move away from the core at great velocities, and only a neutron star or black hole is left as a remnant.

18) Briefly explain why high-mass stars have shorter lifetimes than low-mass stars.

Answer: High-mass stars have 10 to 100 times more mass (fuel) than a typical low-mass star. This greater mass produces a much higher downward gravitational pressure, leading to much higher core temperatures and higher rates of fusion. The luminosity of such stars is therefore 1,000 to 1 million times greater than in low-mass stars. So, although high-mass stars have more fuel to burn, they burn it at a much higher rate and therefore run out of fuel much more quickly.

19) *Process of Science*: Based on what you learned in this chapter, would you expect life to be able to evolve around first-generation stars in our universe? Why or why not?

Answer: Most would say no, as the first-generation stars should not have yet been enriched with the heavy elements we believe are necessary for life. A student could also argue that life could form without these and our current understanding of life is incomplete.

20) *Process of Science:* Explain how patterns in cosmic abundances (Fig 12.15) fit theoretical predictions for the origin of the elements.

Answer: Heavier elements are rarer as they are produced in shorter-lived phases of rare, massive stars. Iron is relatively abundant because its production is energetically favored as the end step of fusion and there is only a short time during the supernova phase when it can be destroyed by fission. The abundances of nuclei with even numbers of protons is greater than neighboring nuclei with odd numbers of protons as expected for nuclear reactions through the addition of helium nuclei.

21) *Process of Science:* How do observations of stars help us understand the theory of atomic nuclei?

Answer: Many nuclear reactions occur during the late stages of stellar evolution. By observing how stars evolve and the production of different elements, we can learn about how nuclei react.

17.4 Mastering Astronomy Reading Quiz

1) Which of the following stars will live longest?

A) a 1-solar-mass star

B) a 2-solar-mass star

C) a 3-solar-mass star

D) a 4-solar-mass star

E) a 5-solar-mass star

Answer: A

2) In the context of understanding stellar lives, "high-mass" stars have masses

A) more than about 8 times the mass of our Sun.

B) more than about 3 times the mass of our Sun.

C) more than twice the mass of our Sun.

D) more than 20 times the mass of our Sun.

Answer: A

3) Which of the following lists the stages of life for a *low-mass* star in the correct order?

A) protostar, main-sequence star, red giant, planetary nebula, white dwarf

B) protostar, main-sequence star, red giant, supernova, neutron star

C) protostar, main-sequence star, planetary nebula, red giant

D) main-sequence star, white dwarf, red giant, planetary nebula, protostar

Answer: A

4) What happens when a main-sequence star exhausts its core hydrogen fuel supply?

A) The entire star shrinks in size.

B) The core shrinks while the rest of the star expands.

C) The core immediately begins to fuse its helium into carbon.

D) The star becomes a neutron star.

Answer: B

5) The main source of energy for a star as it grows in size to become a red giant is

A) hydrogen fusion in the central core.

B) helium fusion in the central core.

C) hydrogen fusion in a shell surrounding the central core.

D) gravitational contraction.

Answer: C

6) The overall helium fusion reaction is

A) three helium nuclei fuse to form one carbon nucleus.

B) two helium nuclei fuse to form one beryllium nucleus.

C) two hydrogen nuclei fuse to form one helium nucleus.

D) four helium nuclei fuse to form one oxygen nucleus.

Answer: A

7) What is a *helium flash*?

A) The ignition of helium shell burning in a high-mass star with a carbon core.

B) A sudden brightening of a low-mass star, detectable from Earth by observing spectral lines of helium.

C) It is another name for the helium fusion reaction.

D) The sudden onset of helium fusion in the core of a low-mass star.

Answer: D

8) An H-R diagram for a globular cluster will show a *horizontal branch*—a line of stars above the main-sequence but to the left of the subgiants and red giants.

Which of the following statements about these horizontal branch stars is *true*?

A) They have inert (non-burning) carbon cores.

B) Their sole source of energy is hydrogen shell burning.

C) They generate energy through both hydrogen fusion and helium fusion.

D) In a particular star cluster, all horizontal branch stars have the same spectral type.

Answer: C

9) What is a planetary nebula?

A) gas created from the remains of planets that once orbited a dead star

B) interstellar gas from which planets are likely to form in the not-too-distant future

C) the remains of a high-mass star that has exploded

D) gas ejected from a low-mass star in the final stage of its life

Answer: D

10) The ultimate fate of our Sun is to

A) explode in a supernova.

B) become a white dwarf that will slowly cool with time.

C) become a rapidly spinning neutron star.

D) become a black hole.

Answer: B

11) Which low-mass star does *not* have fusion occurring in its central core?

A) a main-sequence star

B) a red giant

C) a helium-burning star

Answer: B

12) How are low-mass red giant stars important to our existence?

A) These stars manufactured virtually all the elements out of which we and our planet are made.

B) These stars generate the energy that makes life on Earth possible.

C) These stars manufactured most of the carbon atoms in our bodies.

D) These stars provide most of the light that reaches us from globular clusters.

Answer: C

13) Which of the following pairs of atomic nuclei would feel the *strongest* repulsive electromagnetic force if you tried to push them together?

A) helium and helium

B) hydrogen and hydrogen

C) hydrogen and helium

D) hydrogen and deuterium

Answer: A

14) Which of the following stars will *certainly* end its life in a supernova?

A) the Sun

B) a red giant star

C) a 10-solar-mass star

D) a neutron star

Answer: C

15) What is the CNO cycle?

A) a set of steps by which four hydrogen nuclei fuse into one helium nucleus

B) the process by which helium is fused into carbon, nitrogen, and oxygen

C) the process by which carbon is fused into nitrogen and oxygen

D) the set of fusion reactions that have produced all the carbon, nitrogen, and oxygen in the universe

Answer: A

16) In order to predict whether a star will eventually fuse oxygen into a heavier element, what do you need to know about the star?

A) its luminosity

B) its overall abundance of elements heavier than helium

C) how much oxygen it now has in its core

D) its mass

Answer: D

17) Why is iron significant to understanding how a supernova occurs?

A) Iron is the heaviest of all atomic nuclei, and thus no heavier elements can be made.

B) Supernovae often leave behind neutron stars, which are made mostly of iron.

C) The fusion of iron into uranium is the reaction that drives a supernova explosion.

D) Iron cannot release energy either by fission or fusion.

Answer: D

18) After a supernova explosion, the remains of the stellar core

A) will always be a neutron star.

B) be either a neutron star or a black hole.

C) will always be a black hole.

D) may be either a white dwarf, neutron star, or black hole

Answer: B

19) Why is *Supernova 1987A* particularly important to astronomers?

A) It is the nearest supernova to have occurred at a time when we were capable of studying it carefully with telescopes.

B) It was the first supernova detected in nearly 400 years.

C) It provided the first evidence that supernovae really occur.

D) It occurred only a few light-years from Earth.

Answer: A

20) Algol consist of a 3.7 *M*Sun main-sequence star and a 0.8 *M*Sun subgiant. Why does this seem surprising, at least at first?

A) The two stars in a binary system should both be at the same stage of life; that is, they should either both be main-sequence stars or both be subgiants.

B) It doesn't make sense to find a subgiant in a binary star system.

C) The two stars should be the same age, so we'd expect the subgiant to be more massive than the main-sequence star.

D) A star with a mass of 3.7 *M*Sun is too big to be a main-sequence star.

Answer: C

21) Where does gold (the element) come from?

A) It is produced by mass transfer in close binaries.

B) It is produced during the supernova explosions of high-mass stars.

C) It is produced during the late stages of fusion in low-mass stars.

D) It was produced during the Big Bang.

Answer: B

17.5 Mastering Astronomy Concept Quiz

1) Sun is considered to be a

A) low-mass star.

B) intermediate-mass star

C) high-mass star.

D) brown dwarf.

Answer: A

2) Which of the following types of data provide evidence that helps us understand the life tracks of *low-mass* stars?

A) H-R diagrams of open clusters

B) observing a low-mass star over many years

C) H-R diagrams of globular clusters

D) spacecraft observations of the Sun

Answer: C

3) Why is a 1 solar-mass red giant more luminous than a 1 solar-mass main-sequence star?

A) The red giant has a hotter core.

B) The red giant's surface is hotter.

C) The red giant is more massive.

D) Fusion reactions are producing energy at a greater rate in the red giant.

Answer: D

4) Which of the following describes a star with a hydrogen-burning shell and an inert helium core?

A) It is a red giant that grows in luminosity until it dies in a planetary nebula.

B) It is a subgiant that gradually grows dimmer as its hydrogen-burning shell expands and cools.

C) It is a subgiant that grows in luminosity until helium fusion begins in the central core.

D) It is what is known as a helium-burning star, which has both helium fusion in its core and hydrogen fusion in a shell.

Answer: C

5) Which of the following observations would *not* be likely to provide information about the final, explosive stages of a star's life?

A) studying the light rings around Supernova 1987A in the Large Magellanic Cloud

B) decades of continuous monitoring of red giants in a globular cluster

C) observing the structures of planetary nebulae

D) neutrino detections from nearby supernovae

Answer: B

6) Which is more common: a star blows up as a supernova, or a star forms a planetary nebula/white dwarf system?

A) Supernovae are more common.

B) Planetary nebula formation is more common.

C) They both occur in about equal numbers.

D) It is impossible to say.

Answer: B

*This diagram represents the life track of a 1-solar-mass star. Refer to the life stages labeled with Roman numerals.*



7) During which stage is the star's energy supplied by primarily by gravitational contraction?

A) II

B) III

C) V

D) VI

E) VII

Answer: A

8) During which stage does the star have an inert (non-burning) *helium* core?

A) III

B) IV

C) VI

D) VII

E) VIII

Answer: B

9) Which stage lasts the longest?

A) I

B) VI

C) III

D) VIII

Answer: C

10) During which stage does the star have an inert (non-burning) *carbon* core surrounded by shells of helium and hydrogen burning?

A) II

B) III

C) VI

D) VII

E) VIII

Answer: E

11) What will happen to the star *after* stage VIII?

A) Its outer layers will be ejected as a planetary nebula and its core will become a white dwarf.

B) It will continue to expand gradually until carbon fusion begins in its core.

C) It will explode as a supernova and leave a neutron star or black hole behind.

D) It will remain in stage VIII for about 10 billion years, after which its outer layers will shrink back and cool.

Answer: A

12) Carbon fusion occur in high-mass stars but not in low-mass stars because

A) the cores of low-mass stars never contain significant amounts of carbon.

B) the cores of low-mass stars never get hot enough for carbon fusion.

C) only high-mass stars do fusion by the CNO cycle.

D) carbon fusion can occur only in the stars known as carbon stars.

Answer: B

13) Which of the following statements about various stages of core nuclear burning (hydrogen, helium, carbon, etc.) in a high-mass star is *not* true?

A) As each stage ends, the core shrinks and heats further.

B) Each successive stage creates an element with a higher atomic number and atomic mass number.

C) As each stage ends, the reactions that occurred in previous stages continue in shells around the core.

D) Each successive stage lasts for approximately the same amount of time.

Answer: D

14) Which event marks the beginning of a supernova?

A) the sudden collapse of an iron core into a compact ball of neutrons

B) the onset of helium burning after a helium flash

C) the beginning of neon burning in an extremely massive star

D) the sudden initiation of the CNO cycle

Answer: A

15) Suppose that the star Betelgeuse (the upper left shoulder of Orion) were to supernova tomorrow (as seen here on Earth). What would it look like to the naked eye?

A) Betelgeuse would remain a dot of light, but would suddenly become so bright that, for a few weeks, we'd be able to see this dot in the daytime.

B) We'd see a cloud of gas expanding away from the position where Betelgeuse used to be. Over a period of a few weeks, this cloud would fill our entire sky.

C) Because the supernova destroys the star, Betelgeuse would suddenly disappear from view.

D) Betelgeuse would suddenly appear to grow larger in size, soon reaching the size of the full Moon. It would also be about as bright as the full Moon.

Answer: A

16) Suppose that hydrogen, rather than iron, had the lowest mass per nuclear particle. Which of the following would be true?

A) Stars would be brighter.

B) Stars would be less massive.

C) All stars would be red giants.

D) Nuclear fusion could not power stars.

Answer: D

17) Observations show that elements with atomic mass numbers divisible by 4 (such as oxygen-16, neon-20, and magnesium-24) tend to be more abundant in the universe than elements with atomic mass numbers in between. Why do we think this is the case?

A) The apparent pattern is thought to be a random coincidence.

B) Elements with atomic mass numbers divisible by 4 tend to be more stable than elements in between.

C) At the end of a high-mass star's life, it produces new elements through a series of helium capture reactions.

D) This pattern in elemental abundances was apparently determined during the first few minutes after the Big Bang.

Answer: C

18) A spinning neutron star has been observed at the center of a

A) planetary nebula.

B) supernova remnant.

C) red supergiant.

D) protostar.

Answer: B

19) You discover a binary star system in which one star is a 15 *M*Sun main-sequence star and the other is a 10 *M*Sun giant. How do we think that a star system such as this might have come to exist?

A) The giant must once have been the more massive star, but is now less massive because it transferred some of its mass to its companion.

B) Although both stars probably formed from the same clump of gas, the more massive one must have had its birth slowed so that it became a main-sequence stars millions of years later than its less massive companion.

C) The two stars probably were once separate, but became a binary when a close encounter allowed their mutual gravity to pull them together.

D) The two stars are simply evolving normally and independently, and one has become a giant before the other.

Answer: A

20) Tidal forces are very important to the Algol system today, but were not important when both stars were still on the main sequence. Why not?

A) Main-sequence stars in a system like the Algol system are small compared to their physical separation.

B) Main-sequence stars are too big to be affected by tidal forces.

C) Main-sequence stars are too massive to be affected by tidal forces.

D) Main-sequence stars are unaffected by tidally-induced mass transfer.

Answer: A