

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) The ESA satellite which gave us our most accurate distances to stars is called:

- A) Giotto.
- B) Galileo.
- C) Huygens.
- D) Hipparcos.
- E) Rosetta.

Answer: D

Diff: 2 Page Ref: 17.1R

2) If a star has a parallax of $0.05''$, then its distance in light years is about:

- A) 6.4 light years.
- B) 12.7 light years.
- C) 20 light years.
- D) 65 light years.
- E) 100 light years.

Answer: D

Diff: 2 Page Ref: 17.1R

3) If a star is found by spectroscopic observations to be about 500 parsecs distant, its parallax is:

- A) $.2''$
- B) $.5''$
- C) $.02''$
- D) $.002''$
- E) $.005''$

Answer: D

Diff: 2 Page Ref: 17.1R

4) Hipparcos' observations have given us good data on stars out to about:

- A) 100 light years.
- B) 200 light years.
- C) 200 parsecs.
- D) 1000 light years.
- E) 1000 parsecs.

Answer: C

Diff: 3 Page Ref: 17.1R

5) About how many stars has Hipparcos given us accurate distance data on?

- A) about 3,000, about half of what you can see with the naked eye alone
- B) over 6000, the visible naked eye stars and some seen in binoculars
- C) 60,000, those within about 100 light years of us
- D) a million, those with parallaxes of $.005''$ or larger
- E) over 100 billion, almost every star in the galaxy

Answer: D

Diff: 3 Page Ref: 17.1R

6) What is the absolute magnitude of our Sun?

- A) -23.0
- B) -4.6
- C) -1.4
- D) +4.8
- E) +9.4

Answer: D

Diff: 2 Page Ref: 17.1R

7) Which statement about stellar motion is incorrect?

- A) In general, the closer a star is, the more its proper motion.
- B) The radial velocity is measured by the Doppler shift.
- C) The transverse velocity is measured by the proper motion and the distance.
- D) Like parallax, proper motion is measured over intervals of exactly six months.
- E) The Pythagorean theorem relates space, transverse, and radial velocities.

Answer: D

Diff: 2 Page Ref: 17.1R

8) A nearby star has a parallax of 0.2 arc seconds. What is its distance?

- A) .1 parsec
- B) .2 parsec
- C) .5 parsec
- D) 5 parsecs
- E) 50 parsecs

Answer: D

Diff: 1 Page Ref: 17.1R

9) Procyon lies about 13 light years distant, thus its parallax is about:

- A) 0.01"
- B) 0.25"
- C) 0.40"
- D) 0.65"
- E) 1.3"

Answer: B

Diff: 3 Page Ref: 17.1R

10) What is proper motion?

- A) It is the true, not apparent, motion of a star in space.
- B) It is the apparent shift as we go to opposite sides of our orbit every six months.
- C) It is the annual apparent motion of a star across the sky.
- D) It is the motion of a star towards or away from us, revealed by Doppler shifts.
- E) It is the orbital motion of a star around the Galaxy.

Answer: C

Diff: 1 Page Ref: 17.1R

11) In order to turn a star's proper motion into its space velocity, we must also know:

- A) its mass and spectral type.
- B) its temperature and age.
- C) its distance and radial velocity.
- D) its distance and mass.
- E) its spectral type and period of rotation.

Answer: C

Diff: 3 Page Ref: 17.1R

12) Which of the following best describes the size and distance relationship of our Sun and the nearest star?

- A) a tennis ball here, another on the Moon
- B) two beach balls separated by 100 city blocks
- C) two grains of sand separated by 100 light years
- D) two golf balls separated by 100 kilometers
- E) two baseballs separated by 100 yards

Answer: D

Diff: 2 Page Ref: 17.1R

13) The absolute magnitude of a star is its brightness as seen from a distance of:

- A) one million kilometers.
- B) one astronomical unit.
- C) one light year.
- D) ten parsecs.
- E) 10 light years.

Answer: D

Diff: 2 Page Ref: 17.2R

14) Which of the following apparent magnitudes is the brightest?

- A) -23
- B) -1.4
- C) +4.8
- D) +9.2
- E) +25.7

Answer: A

Diff: 1 Page Ref: 17.2R

15) Perhaps the greatest of the Greek astronomers, _____ compiled the first catalog of stars, accurately measured their positions, and defined the basic system of stellar brightnesses.

- A) Erastheneas
- B) Aristotle
- C) Ptolemy
- D) Hipparchus
- E) Aristarchus

Answer: D

Diff: 2 Page Ref: 17.2R

16) Two stars which differ by 5 magnitudes in apparent brightness have the same parallax; thus, one star must be intrinsically _____ times as luminous as the other.

- A) 2.5
- B) 5
- C) 20
- D) 100
- E) 1,000

Answer: D

Diff: 2 Page Ref: 17.2R

17) In comparing first magnitude Deneb with second magnitude Polaris, we find that:

- A) Polaris is in reality much more luminous.
- B) Deneb must be much hotter than Polaris.
- C) Deneb appears 2.5X brighter to us than does Polaris.
- D) Polaris is really 100X brighter than nearby Deneb.
- E) Deneb is really much closer than Polaris.

Answer: C

Diff: 2 Page Ref: 17.2R

18) If two stars differ in brightness by 5 magnitudes, the light ratio received by us is:

- A) 2.5:1.
- B) 6:1.
- C) 50:1.
- D) 100:1.
- E) 250:1.

Answer: D

Diff: 2 Page Ref: 17.2R

19) What are the two most important intrinsic properties used to classify stars?

- A) mass and age
- B) luminosity and surface temperature
- C) distance and luminosity
- D) distance and surface temperature
- E) distance and color

Answer: B

Diff: 1 Page Ref: 17.3R

20) Which of the following spectral types is the hottest?

- A) G2
- B) H3
- C) K4
- D) G5
- E) M9

Answer: A

Diff: 1 Page Ref: 17.3R

21) While Sirius, the Dog Star, is type A0, a star just a step hotter than M0 is a related:

- A) M1.
- B) K9.
- C) F5.
- D) A0K.
- E) B9.

Answer: B

Diff: 2 Page Ref: 17.3R

22) Which of the following spectral types is the hottest?

- A) M5
- B) G2
- C) K9
- D) O5
- E) A0

Answer: D

Diff: 2 Page Ref: 17.3R

23) Which of these pairs of spectral types is most similar in temperature?

- A) G2 and G9
- B) B1 and A1
- C) F1 and G9
- D) K9 and M0
- E) M2 and M5

Answer: D

Diff: 2 Page Ref: 17.3R

24) What physical property of a star does the spectral type measure?

- A) density
- B) luminosity
- C) temperature
- D) mass
- E) composition

Answer: C

Diff: 1 Page Ref: 17.3R

25) The star's color index is a quick way of determining its:

- A) density.
- B) luminosity.
- C) mass.
- D) temperature.
- E) composition.

Answer: D

Diff: 2 Page Ref: 17.3R

26) The hydrogen lines are most evident in class _____ stars.

- A) H-I
- B) A
- C) B
- D) M
- E) W

Answer: B

Diff: 2 Page Ref: 17.3N

27) Strongly lines of singly ionized helium are evident only in type:

- A) A.
- B) B.
- C) H.
- D) N.
- E) O.

Answer: E

Diff: 2 Page Ref: 17.3N

28) Molecular bands are most evident in class:

- A) A.
- B) B.
- C) G.
- D) M.
- E) O.

Answer: D

Diff: 2 Page Ref: 17.3N

29) The most famous G type star is:

- A) Polaris.
- B) Betelgeuse.
- C) Sirius.
- D) the Sun.
- E) Pollux.

Answer: D

Diff: 2 Page Ref: 17.3N

30) At what temperature are the hydrogen lines most prominent?

- A) 3,000 K
- B) 5,800 K
- C) 10,000 K
- D) 24,000 K
- E) 50,000 K

Answer: C

Diff: 3 Page Ref: 17.3N

31) Stars that have masses similar to the Sun's, and sizes similar to the Earth are:

- A) main sequence stars.
- B) white dwarfs.
- C) red giants.
- D) red dwarfs.
- E) brown dwarfs.

Answer: B

Diff: 1 Page Ref: 17.4R

32) Compared to the size of the Sun, between what range of sizes are most stars found?

- A) .5 to 2 solar radii
- B) 0.1 to 1.0 solar radii
- C) 0.5 to 50 solar radii
- D) 1 to 100 solar radii
- E) 0.01 to 100 solar radii

Answer: E

Diff: 2 Page Ref: 17.4R

33) How might the most common occurring stars be described, based on our stellar neighborhood?

- A) white dwarfs
- B) K giants
- C) G main sequence
- D) A main sequence
- E) M main sequence

Answer: E

Diff: 2 Page Ref: 17.5R

34) On the H-R diagram, red supergiants like Betelgeuse lie:

- A) at the bottom left.
- B) at the bottom right.
- C) at the top left.
- D) at the top right.
- E) They can't be plotted, for they are not main sequence.

Answer: D

Diff: 2 Page Ref: 17.5R

35) On the H-R diagram, white dwarfs lie Sirius B and Procyon B lie:

- A) at the top left.
- B) at the top right.
- C) close to the Sun, near the center.
- D) at the lower left.**
- E) at the lower right.

Answer: D

Diff: 2 Page Ref: 17.5R

36) On the H-R diagram, the Sun lies:

- A) at the top left.
- B) at the bottom left.
- C) at the bottom right.
- D) about the middle of the main sequence.**
- E) at the top right.

Answer: D

Diff: 1 Page Ref: 17.5R

37) In the H-R diagram, the bright blue-white stars that dominate the naked eye sky lie to the:

- A) top left.**
- B) top right.
- C) middle of the main sequence.
- D) top center.
- E) bottom left.

Answer: A

Diff: 2 Page Ref: 17.5R

38) The HR diagram can be a plot of:

- A) luminosity versus mass.
- B) absolute magnitude versus spectral type.**
- C) color index versus spectral type.
- D) size versus mass.
- E) temperature versus density.

Answer: B

Diff: 2 Page Ref: 17.5R

39) Which of the following is the most common type of star?

- A) high mass main sequence
- B) low mass main sequence**
- C) white dwarfs
- D) red giants
- E) blue supergiants

Answer: B

Diff: 1 Page Ref: 17.5R

40) The Hertzsprung-Russell Diagram plots _____ against the spectral type or temperature.

- A) distance
- B) luminosity or absolute magnitude**
- C) brightness or apparent magnitude
- D) size or density
- E) mass

Answer: B

Diff: 1 Page Ref: 17.5R

41) Having nothing to do with trigonometry, _____ parallaxes use the width of absorption lines to estimate the star's luminosity and size and distance.

- A) bolometric
- B) photometric
- C) spectroscopic
- D) holographic
- E) videometric

Answer: C

Diff: 1 Page Ref: 17.6N

42) The entire spectral classification of our Sun is:

- A) M5V.
- B) G2Ib.
- C) G2V.
- D) K9III.
- E) not given.

Answer: C

Diff: 2 Page Ref: 17.6N

43) In general, the narrower the spectral line of a star:

- A) the hotter the star is.
- B) the bigger the star is.
- C) the denser the star is.
- D) the smaller the star is.
- E) the cooler the star is.

Answer: B

Diff: 2 Page Ref: 17.6N

44) Betelgeuse, the red supergiant, is:

- A) K9V.
- B) M3V.
- C) O9Ic.
- D) M2Ia.
- E) B7Iaa.

Answer: D

Diff: 3 Page Ref: 17.6N

45) Upon what data do measurements of sizes of eclipsing binaries depend?

- A) their orbital periods and separations
- B) their masses and luminosities
- C) their Doppler shifts and durations of stages of their eclipses
- D) their temperatures and speeds
- E) their temperatures and masses

Answer: C

Diff: 2 Page Ref: 17.7R

46) Which type of binary can have their sizes measured directly by photometry?

- A) virtual
- B) visual
- C) eclipsing
- D) spectroscopic
- E) astrometric

Answer: C

Diff: 2 Page Ref: 17.7R

47) What characteristic of the stars in a binary system can be determined by knowing the period of the stars' common orbit and the distance between them?

- A) their apparent brightnesses
- B) their absolute magnitudes
- C) their densities
- D) their masses
- E) their temperatures

Answer: D

Diff: 1 Page Ref: 17.7R

48) In what range of masses are most stars found?

- A) .1 to 2 solar masses
- B) 1 to 3 solar masses
- C) .1 to 100 solar masses
- D) .01 to 100 solar masses
- E) Stars can have any mass.

Answer: C

Diff: 2 Page Ref: 17.7R

49) Stellar masses are determined directly by observation of the orbits and periods of:

- A) only eclipsing binary systems.
- B) only spectroscopic binary systems.
- C) only visual binary systems.
- D) only astrometric binary systems.
- E) any binary system.

Answer: E

Diff: 2 Page Ref: 17.7R

50) In a spectroscopic binary system, the star showing the larger blue shift is:

- A) cooler and receding the fastest.
- B) less massive of the pair and receding slower.
- C) more massive and approaching us.
- D) less massive and approaching us at this moment.
- E) hotter and receding faster.

Answer: D

Diff: 3 Page Ref: 17.7N

51) In a spectroscopic binary, if a pair shows a combined set of lines tonight, but a maximum split two nights later, its orbital period must be:

- A) one day.
- B) two days.
- C) four days.
- D) eight days.
- E) twelve days.

Answer: D

Diff: 3 Page Ref: 17.7N

52) In a visual binary system with circular orbits, if in 20 years the two stars' position angles have shifted by 30 degrees, the pair's period must be:

- A) 60 years.
- B) 90 years.
- C) 120 years.
- D) 240 years.
- E) 360 years.

Answer: D

Diff: 2 Page Ref: 17.7N

53) What is the typical main sequence lifetime of a M-type star?

- A) one million years
- B) ten million years
- C) one billion years
- D) ten billion years
- E) a trillion years

Answer: E

Diff: 3 Page Ref: 17.8R

54) What is the typical main sequence lifetime of a G-type star?

- A) 10 million years
- B) 100 million years
- C) 1 billion years
- D) 10 billion years
- E) 100 billion years

Answer: D

Diff: 3 Page Ref: 17.8R

55) What is the single most important characteristic in determining the course of a star's evolution?

- A) density
- B) absolute brightness
- C) distance
- D) surface temperature
- E) mass

Answer: E

Diff: 1 Page Ref: 17.8R

56) What is the typical main sequence lifetime of a B-type star?

- A) less than a million years
- B) 20 million years
- C) 100 million years
- D) 1 billion years
- E) 10 billion years

Answer: B

Diff: 3 Page Ref: 17.8R

57) The star's luminosity is related to its mass by:

- A) M^2 .
- B) $M^{2.5}$.
- C) M^3 .
- D) M^4 .
- E) $1/M$.

Answer: D

Diff: 3 Page Ref: 17.8N

58) The main sequence lifetime of a star is given by the ratio of:

- A) L/M^2 .
- B) M/L .
- C) M/L^3 .
- D) R^2/M .
- E) T^4/M .

Answer: B

Diff: 2 Page Ref: 17.8N

59) The main sequence lifetime of star is related to its mass by:

- A) M^3 .
- B) $1/M$.
- C) M^2 .
- D) $1/M^3$.
- E) $1/M^4$.

Answer: D

Diff: 2 Page Ref: 17.8N

60) For a star of 10 solar masses, its main sequence life span will be:

- A) ten times longer than our Sun's.
- B) about the same as the Sun's.
- C) only a tenth of the Sun's.
- D) about a hundred times less than the Sun's.
- E) only 1/1000th of the Sun.

Answer: E

Diff: 3 Page Ref: 17.8N

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) What makes the subject of star formation so difficult and complex?

- A) It is so slow that no visible proof of it exists.
- B) Star formation is too expensive to study in detail.
- C) Stars live too long to be observed from birth to death.
- D) Clouds, fragments, protostars, stars, and nebulae all interact and influence each other.
- E) Shock waves disrupt the orderly evolution of stars.

Answer: C

Diff: 1 Page Ref: 19.1R

2) When an H II region is observed, it signals what stage in stellar formation?

- A) the initial collapse of the interstellar cloud
- B) the formation of planetary nebulae
- C) the protostar stage
- D) the zero-age main sequence stage
- E) Depending on their masses, the stars inside may be at different stages of formation.

Answer: E

Diff: 2 Page Ref: 19.1R

3) What is the size of a typical interstellar cloud that is dense enough to form stars?

- A) 10 A.U.
- B) 100 A.U.
- C) 1,000 A.U.
- D) 10 parsecs
- E) 100 light years

Answer: D

Diff: 2 Page Ref: 19.1R

4) How many hydrogen atoms does it take to make a typical star?

- A) 10^6
- B) 10^{10}
- C) 10^{18}
- D) 10^{25}
- E) 10^{57}

Answer: E

Diff: 3 Page Ref: 19.2R

5) What is the critical temperature at which hydrogen can fuse into helium in the star's core?

- A) 5,800 K
- B) 26,000 K
- C) one million K
- D) ten million K
- E) 100 million K

Answer: D

Diff: 1 Page Ref: 19.2R

6) What is characteristic of a main sequence star?

A) It has a mass less than the Sun's.

B) It has rapid rotation and a strong stellar wind.

C) Nuclear fusion in the core varies due to the amount of gravitational contraction that occurs and which heavy elements are produced.

D) The rate of nuclear energy generated in the hydrogen to helium fusing core equals the rate radiated from the surface.

E) All of the above are correct.

Answer: D

Diff: 2 Page Ref: 19.2R

7) How long does it take for a star like our Sun to form?

A) 100 thousand years

B) two million years

C) fifty million years

D) one billion years

E) 4.6 billion years

Answer: C

Diff: 2 Page Ref: 19.2R

8) Which event marks the birth of a star?

A) formation of the planetary nebula

B) fusion of hydrogen atoms into helium atoms

C) collapse of an interstellar cloud

D) formation of a photosphere

E) instability in an interstellar cloud

Answer: B

Diff: 1 Page Ref: 19.2R

9) How long does it take an M-type star to form, compared to the time for a solar-type star to form?

A) half as long

B) about the same time

C) twice as long

D) 20 times as long

E) 200 times as long

Answer: E

Diff: 2 Page Ref: 19.3R

10) If the initial interstellar cloud in star formation has a mass sufficient to form hundreds of stars, how does a single star form from it?

A) One star forms at its center and blows the rest of the matter back into space.

B) The cloud fragments into smaller clouds and forms many stars at one time.

C) One star forms and the rest of the matter goes into making planets, moons, and other objects of a solar system.

D) The cloud is disrupted by rotation so that it reduces its mass down to that of a typical star.

E) A supernova blows the cloud up and dissipates the majority of the gas.

Answer: B

Diff: 2 Page Ref: 19.3R

11) For gravity to contract a spinning interstellar cloud, there needs to be sufficient:

- A) charged ions.
- B) heat.
- C) mass and density.
- D) magnetism.
- E) rotation.

Answer: C

Diff: 1 Page Ref: 19.3R

12) What is the key factor that determines the temperature, density, radius, luminosity, and pace of evolution of a protostellar object?

- A) composition of the nebula
- B) rotation of the nebula
- C) mass of the nebula
- D) temperature of the nebula
- E) magnetism of the nebula

Answer: C

Diff: 1 Page Ref: 19.3R

13) Which relationship concerning the mass of protostars is false?

- A) The more massive ones will reach the main sequence first.
- B) The more massive ones will be the hottest and most luminous.
- C) The more massive ones one will be made of the heaviest elements.
- D) The more massive ones are so luminous they ionize the gas, hence red H II regions.
- E) The more massive ones create a lot of ultraviolet as well as visible light.

Answer: C

Diff: 2 Page Ref: 19.3R

14) How are T Tauri stars characterized observationally?

- A) by sudden changes in their brightness
- B) by very high temperatures
- C) by very high magnetic fields and large starspots
- D) by very rapid rotation
- E) They are newly-formed stars that are short period binaries.

Answer: A

Diff: 2 Page Ref: 19.4R

15) A typical protostar may be several thousand times more luminous than the Sun. What is the source of this energy?

- A) chemical combustion of hydrocarbons
- B) nuclear fusion in its core
- C) from the release of gravitational energy as the protostar continues to shrink
- D) the ionization of the gas as it heats up
- E) from nearby hot stars or supernovae that have initiated the star formation process

Answer: C

Diff: 2 Page Ref: 19.4R

16) Which of these is NOT typical of a condensing protostar?

- A) magnetic fields producing polar flows
- B) dusty disks around their equators
- C) Herbig-Haro objects projecting a light year out in space
- D) fusion of helium into carbon in their cores
- E) more infrared than visible light given off from the cocoon of dust around the star

Answer: D

Diff: 2 Page Ref: 19.4R

17) _____ variable stars are pre-Main Sequence stars undergoing gravitational contraction and exhibiting erratic changes in their luminosities.

- A) R Coronae Borealis
- B) RR Lyrae
- C) Cepheid
- D) T Tauri
- E) Herbig-Haro

Answer: D

Diff: 2 Page Ref: 19.4R

18) What happens when an interstellar cloud fragment shrinks?

- A) It first becomes opaque.
- B) Density rises.
- C) Temperature rises.
- D) Pressure rises.
- E) all of the above

Answer: E

Diff: 1 Page Ref: 19.4R

19) As a star forms, the photosphere first appears:

- A) when the planetary nebula is expelled.
- B) when the protostar forms.
- C) when contraction slows down.
- D) when nuclear fires ignite.
- E) when the star reaches the main sequence.

Answer: B

Diff: 2 Page Ref: 19.4R

20) A cloud fragment too small to form a star becomes:

- A) a red giant.
- B) a black hole.
- C) a brown dwarf.
- D) a T Tauri object.
- E) a Herbig Haro object.

Answer: C

Diff: 1 Page Ref: 19.4R

21) At what stage of evolution do T Tauri stars occur?

- A) just as the collapsing cloud becomes luminous
- B) when a protostar is on the verge of becoming a main sequence star
- C) just prior to the protostar stage
- D) just after the planetary nebula is expelled
- E) after the star has established itself as a main sequence star

Answer: B

Diff: 2 Page Ref: 19.4R

22) Which of these is NOT a source of the shock waves that lead to protostars?

- A) radiation from the OB stars in emission nebulae
- B) expanding Herbig-Haro objects
- C) expanding planetary nebula shells
- D) violent supernovae explosions
- E) collisions between galaxies

Answer: B

Diff: 1 Page Ref: 19.5N

23) When a typical open cluster forms, which type of stars are formed most often?

- A) solar type stars of class G
- B) OB associations
- C) red giants
- D) low mass M type dwarfs
- E) white dwarfs

Answer: D

Diff: 2 Page Ref: 19.6R

24) Evidence for star formation theory comes from:

- A) studies of molecules at close to absolute zero.
- B) tracking one star through time.
- C) plotting stars as they move about on the Hertzsprung-Russell diagram.
- D) studying different objects at different stages and piecing together an evolutionary picture.
- E) observations of dark and emission nebulae.

Answer: D

Diff: 2 Page Ref: 19.6R

25) Most stars probably formed:

- A) alone.
- B) in intergalactic space, then were swept up into the Galaxy.
- C) in clusters in the Galaxy's spiral arms.
- D) from planetary nebulae.
- E) in the galactic Nucleus, then migrated outward later.

Answer: C

Diff: 1 Page Ref: 19.6R

26) What are the characteristics of globular cluster stars?

- A) no stars as hot as our Sun
- B) old age and hundreds of thousands to millions of member stars
- C) no main sequence stars left, with billions of member stars
- D) a few hundred stars, most still on the main sequence
- E) hundreds of light years across, with bright OB stars dominant

Answer: B

Diff: 2 Page Ref: 19.6R

27) Why are star clusters almost ideal "laboratories" for stellar studies?

- A) All stars in the cluster are the same size and luminosity.
- B) Their combined light makes them much easier to spot from a distance.
- C) Stars in clusters have the same age, similar composition, and are at the same distance away.
- D) Stars in clusters are all relatively young and therefore shine brightly.
- E) Like our Sun, stars in clusters are always located in the plane of the Milky Way Galaxy.

Answer: C

Diff: 1 Page Ref: 19.6R

28) What are the characteristics of an open cluster of stars?

- A) mostly found above and below the galactic plane
- B) old age and millions of members
- C) a few hundred, mainly main sequence stars
- D) all stars are much more massive than our Sun
- E) all stars are about the same age and luminosity

Answer: C

Diff: 2 Page Ref: 19.6R

29) Star clusters have been observed within dark nebulae with:

- A) optical movies made over decades.
- B) radio interferometers.
- C) infrared observations.
- D) the Chandra X-Ray observatory.
- E) ultraviolet light creating the emission nebulae.

Answer: C

Diff: 2 Page Ref: 19.6N

30) On the H-R diagrams of clusters, which statement is NOT true?

- A) For young clusters, almost every star is still on the main sequence.
- B) The brightest stars in old globulars are red giants.
- C) The open clusters have as many members as the globulars, but spread their stars out over a much larger volume.
- D) The turn-off point will be lower down the main sequence for older clusters.
- E) We now observe only formation of open, not globular clusters, near us.

Answer: C

Diff: 2 Page Ref: 19.6N

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) The helium flash converts three helium nuclei to the heavier element:

- A) beryllium.
- B) boron.
- C) lithium.
- D) carbon.
- E) iron.

Answer: D

Diff: 1 Page Ref: 20.1R

2) How many helium atoms must undergo fusion at 100 million K in the helium flash?

- A) two
- B) three
- C) four
- D) six
- E) It varies with density.

Answer: B

Diff: 2 Page Ref: 20.1R

3) Which statement is true, in terms of stellar evolution?

- A) There are no discernable trends here.
- B) Sooner or later, gravity loses.
- C) Sooner or later, gravity wins.
- D) Sometimes gravity wins and sometimes gravity loses.
- E) Gravity lets up under certain circumstances.

Answer: C

Diff: 1 Page Ref: 20.1R

4) What temperature is needed to fuse helium into carbon?

- A) 5,800 K
- B) 100,000 K
- C) 15 million K
- D) 100 million K
- E) one billion K

Answer: D

Diff: 2 Page Ref: 20.1R

5) What inevitably forces a star like the Sun to evolve away from being a main sequence star?

- A) The core begins fusing iron.
- B) The star uses up all its supply of hydrogen.
- C) The carbon detonation explodes it as a type I supernova.
- D) Helium builds up in the core, while the hydrogen burning shell expands.
- E) The core loses all its neutrinos, so all fusion ceases.

Answer: D

Diff: 2 Page Ref: 20.1R

6) A star spends most of its life:

- A) as a protostar.
- B) as a main sequence star.
- C) as a planetary nebula.
- D) as a red giant or supergiant.
- E) as a T Tauri variable star.

Answer: B

Diff: 1 Page Ref: 20.1R

7) What is the significance of 100 million K to the core of a star?

- A) temperature needed to fuse deuterium for brown dwarfs
- B) temperature to fuse hydrogen into helium in the proton-proton cycle
- C) temperature needed to fuse iron and create a type II supernova
- D) temperature need to start triple alpha process and turn helium into carbon
- E) temperature needed to fuse carbon into oxygen

Answer: D

Diff: 2 Page Ref: 20.1R

8) Just as a low-mass main sequence star runs out of fuel in its core, it actually becomes brighter. How is this possible?

- A) Helium fusion gives more energy than hydrogen fusion does, based on masses.
- B) Its outer envelope is stripped away and we see the brilliant core.
- C) The core contracts, raising the temperature and increasing the size of the region of hydrogen shell-burning.
- D) It explodes.
- E) It immediately starts to fuse helium.

Answer: C

Diff: 2 Page Ref: 20.2R

9) The "helium flash" occurs at what stage in stellar evolution?

- A) when the T Tauri bipolar jets shoot out
- B) in the middle of the main sequence stage
- C) red giant
- D) horizontal branch
- E) planetary nebula

Answer: C

Diff: 2 Page Ref: 20.2R

10) Can a star become a red giant more than once?

- A) Yes.
- B) No, it loses too much mass the first time.
- C) No, it becomes a planetary nebula only once.
- D) No, it explodes then collapses to a white dwarf.
- E) No, there are no recurrent supernovae.

Answer: A

Diff: 2 Page Ref: 20.2R

11) What is the source of pressure in the core of a red giant that resists the force of gravity?

- A) electrons which have become incompressible
- B) repulsion of protons within the nuclei
- C) normal thermal pressure of the hot gas
- D) neutrons which resist being pressed together beyond a certain density
- E) helium nuclei which repulse each other strongly because they each contain two protons

Answer: A

Diff: 2 Page Ref: 20.2R

12) The order of evolutionary stages of a star like the Sun would be Main Sequence, giant, planetary nebula, and finally:

- A) hypernova.
- B) neutron star.
- C) white dwarf.
- D) nova.
- E) black hole.

Answer: C

Diff: 2 Page Ref: 20.2R

13) Which of these will the Sun probably become in the very distant future?

- A) hypernova
- B) supernova
- C) pulsar
- D) planetary nebula
- E) nova

Answer: D

Diff: 2 Page Ref: 20.2R

14) What is a planetary nebula?

- A) the bipolar jets ejected by a T Tauri variable
- B) a planet surrounded by a glowing shell of gas
- C) the disc of gas and dust surrounding a young star that will soon form a solar system
- D) the ejected envelope, often bipolar, of a red giant surrounding a stellar core remnant
- E) a type of young, medium mass star

Answer: D

Diff: 1 Page Ref: 20.3R

15) Which of the following is true regarding planetary nebulae?

- A) Some are spherical, but most have bipolar structure.
- B) They are the result of the mass loss during the main sequence stage of the most massive stars.
- C) They are the rings of material surrounding newly formed stars that will eventually form the planetary systems.
- D) They are the ejected envelopes of highly evolved brown dwarf stars.
- E) They are the coronas surrounding most blue stragglers.

Answer: A

Diff: 3 Page Ref: 20.3R

16) What are black dwarfs?

- A) the lowest mass main sequence stars
- B) the end result of massive star evolution
- C) objects that are not quite massive enough to be stars
- D) pulsars that have slowed down and stopped spinning
- E) cooled off white dwarfs that no longer glow visibly

Answer: E

Diff: 1 Page Ref: 20.3R

17) What results from the mass loss from K and M red giants?

- A) Bipolar jets creating Herbig-haro objects.
- B) The wind is rich in dust particles and molecules, including carbon compounds.
- C) Strong ultraviolet emissions causing H II regions.
- D) Very high velocity winds creating cometary globules.
- E) Actually, very little mass is lost, but this dust does scatter light well.

Answer: B

Diff: 3 Page Ref: 20.3R

18) A _____ is a relatively gentle mass-loss event which allows a star to peacefully readjust its structure into a white dwarf configuration.

- A) dark nebula
- B) emission nebula
- C) planetary nebula
- D) nova
- E) supernova

Answer: C

Diff: 1 Page Ref: 20.3R

19) In a white dwarf, we have packed the mass of the sun into the volume of earth, so the density is:

- A) dozens of times that of normal matter.
- B) hundreds of times greater than normal matter.
- C) thousands of times denser than water.
- D) a million times that of the Sun.
- E) trillions of times greater than iron.

Answer: D

Diff: 2 Page Ref: 20.3R

20) The tremendous increase in density in white dwarfs is due to:

- A) iron being denser than hydrogen.
- B) the protons and electrons being fused into neutrons.
- C) the neutrinos all being driven out of the nucleus.
- D) the crushing of the electron orbitals.
- E) the forming of molecular bonds between all atoms.

Answer: D

Diff: 2 Page Ref: 20.3N

21) Which of the following best describes the evolutionary track followed in the HR diagram for the most massive stars?

- A) vertically upward, along the left edge of the diagram
- B) diagonally to lower right, then vertical, then horizontally left
- C) horizontally right, diagonally to lower left, then horizontally right
- D) horizontally right**
- E) horizontally right, then forms a clockwise loop

Answer: D

Diff: 3 Page Ref: 20.4R

22) A high-mass star dies more violently than a low-mass star because:

- A) it must always end up as a black hole.
- B) it generates more heat and its core eventually collapses very suddenly.**
- C) it cannot fuse elements heavier than carbon.
- D) gravity is weakened by its high luminosity.
- E) it is most often found as part of a binary system.

Answer: B

Diff: 1 Page Ref: 20.4R

23) Luminous hot stars and luminous cool stars:

- A) have stellar winds, but each are driven by a different source.**
- B) all are fusing elements up to iron, then exploding.
- C) generate stellar winds of very low velocity.
- D) release dust particles and molecules into interstellar space.
- E) lose an insignificant amount of mass from stellar winds.

Answer: A

Diff: 3 Page Ref: 20.4R

24) Astronomers talk about "low-mass" and "high-mass" stars with regard to their evolution. In units of solar masses, what is the dividing line, that is, the lowest mass for a high-mass star?

- A) 1.4
- B) 3
- C) 5
- D) 8
- E) 12

Answer: D

Diff: 2 Page Ref: 20.4R

25) In the evolution of massive stars, what is the significance of the temperature 600 million K?

- A) It is the temperature at which helium fuses into carbon.
- B) It is the temperature needed for carbon fusing into heavier elements.
- C) It is the main sequence core temperature which makes massive stars so bright.
- D) It is the temperature needed for helium burning into boron.
- E) It is the final temperature reached during their evolution.

Answer: B

Diff: 3 Page Ref: 20.4R

26) What is used, observationally, to determine the age of a star cluster?

- A) radioactive dating of isotopes seen in the spectra
- B) the number of main sequence stars
- C) the luminosity at the main-sequence turnoff
- D) the ratio of the number of giants to supergiants
- E) the number of white dwarfs

Answer: C

Diff: 2 Page Ref: 20.5R

27) What is a typical age for a globular cluster?

- A) 10 million years
- B) 200 million years
- C) one billion years
- D) 4.8 billion years
- E) 12 billion years

Answer: E

Diff: 2 Page Ref: 20.5R

28) In a star cluster, just as the most massive stars are evolving into giants and supergiants, what is happening for the lowest mass stars?

- A) They continue to be main sequence stars.
- B) They are just starting to approach the zero-age main sequence.
- C) They have already collapsed into neutron stars.
- D) They, too, are evolving off the main sequence, but are not as luminous as giants.
- E) Instead, they are evolving into white dwarfs.

Answer: B

Diff: 2 Page Ref: 20.5R

29) Which statement about blue stragglers is false?

- A) The CNO cycle keeps them blue longer than the proton-proton cycle.
- B) They occur in globular star clusters.
- C) In color, they appear younger than other members of the cluster.
- D) They may represent mergers between close binary pairs.
- E) They lie to the upper left of the "turn-off" point for the other cluster members.

Answer: A

Diff: 3 Page Ref: 20.5R

30) In globular clusters, the brightest stars will be:

- A) massive blue main sequence stars.
- B) red supergiants.
- C) T Tauri stars.
- D) blue stragglers.
- E) planetary nebulae.

Answer: B

Diff: 2 Page Ref: 20.5R

31) The brightest stars of a young open cluster will be:

- A) Cepheid variables.
- B) massive blue main sequence stars.
- C) red giants.
- D) yellow main sequence stars like the Sun.
- E) T Tauri variables.

Answer: B

Diff: 1 Page Ref: 20.5R

32) What characteristic of a star cluster is used to determine its age?

- A) the ratio of main sequence to white dwarfs stars
- B) the number of red giants
- C) the faintest stars seen in the cluster
- D) the main sequence turnoff
- E) the total number of stars in the cluster

Answer: D

Diff: 1 Page Ref: 20.5R

33) What, in addition to its HR diagram, is needed to age-date a star cluster?

- A) observations of spectral lines in its oldest white dwarfs
- B) spectra of its brightest stars
- C) at least one eclipsing binary in the cluster
- D) one or more white dwarfs in the cluster
- E) theoretical models of stellar evolution

Answer: E

Diff: 1 Page Ref: 20.5R

34) The evolution of stars appears inevitable. But what likely circumstance can radically alter this evolutionary sequence?

- A) Comets can collide with the star.
- B) The stars can be in a short period binary system.
- C) The stars may pass through a dark dust cloud and gain mass.
- D) The stars may collide with other unrelated stars in the galaxy.
- E) The stars may escape from their star cluster.

Answer: B

Diff: 2 Page Ref: 20.6R

35) If one star of a binary fills its Roche lobe and is spilling matter onto the other, then the system is a:

- A) hypernova.
- B) potential type II supernova.
- C) contact binary.
- D) spectroscopic binary.
- E) mass transfer binary.

Answer: E

Diff: 3 Page Ref: 20.6R

36) If two stellar cores share a single envelope, we have a:

- A) nova.
- B) blue straggler.
- C) black hole.
- D) contact binary.
- E) millisecond pulsar.

Answer: D

Diff: 3 Page Ref: 20.6R

37) The Roche lobe of a star in a binary star system:

- A) resembles the ear of Edouard Roche, a French mathematician.
- B) is, in terms of the star's gravity, its "zone of influence."
- C) is the part of a rapidly rotating star that will eventually spin away to form planets.
- D) is the accretion disc around the companion star.
- E) leads to formation of rings, like around the jovian planets.

Answer: B

Diff: 2 Page Ref: 20.6R

38) That brighter Sirius A weighs 3 solar masses, but the white dwarf Sirius B is only about one solar mass implies:

- A) that white dwarfs evolve slower than main sequence stars.
- B) that the collapsed companion transferred mass to Sirius A.
- C) that there should be a planetary nebula around the Sirius system.
- D) that Sirius A will be stable three times longer than Sirius B.
- E) the Sirius A will end up as a black hole, not a white dwarf like its companion.

Answer: B

Diff: 3 Page Ref: 20.6N

39) The most famous case of a more massive hot star orbiting with a more evolved but presently less massive red giant is the eclipsing binary:

- A) Aldebaran.
- B) Antares.
- C) Algol.
- D) Alberio.
- E) Altair.

Answer: C

Diff: 2 Page Ref: 20.6N

40) Mass transfer in binaries occurs when one giant swells to reach the:

- A) Chandrasekhar Limit.
- B) Cassini Division.
- C) Hayashi Track.
- D) Roche Lobe.
- E) Herbig-Haro Limit.

Answer: D

Diff: 2 Page Ref: 20.6N

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) A surface explosion on a white dwarf, caused by falling matter from the atmosphere of its binary companion, creates what kind of object?

- A) hypernova
- B) nova
- C) gamma ray burstar
- D) type I supernova
- E) type II supernova

Answer: B

Diff: 1 Page Ref: 21.1R

2) For a nova to occur, the system must have already been a:

- A) astrometric binary.
- B) detached binary.
- C) spectroscopic binary.
- D) mass-transfer binary.
- E) eclipsing binary.

Answer: D

Diff: 2 Page Ref: 21.1R

3) The upper mass limit of 1.4 solar masses for white dwarfs won a Nobel Prize for:

- A) Carl Sagan.
- B) Edwin Hubble.
- C) Albert Einstein.

D) Chandrasekhar.

E) Karl Schwarzschild.

Answer: D

Diff: 2 Page Ref: 21.1R

4) The Chandrasekhar mass limit is:

A) .08 solar masses.

B) 4 solar masses.

C) 1.4 solar masses.

D) 3 solar masses.

E) 8 solar masses.

Answer: C

Diff: 2 Page Ref: 21.1R

5) The total energy emitted by the brightest nova explosions is about:

A) 1,000 Suns.

B) 50,000 Suns.

C) a million Suns.

D) a billion Suns.

E) a trillion Suns.

Answer: C

Diff: 2 Page Ref: 21.1R

- 6) An iron core cannot support a star because:
- A) iron is the heaviest element, and sinks upon differentiation.
 - B) iron has poor nuclear binding energy.
 - C) iron cannot fuse with other nuclei to produce energy.
 - D) iron supplies too much pressure.
 - E) iron is in the form of a gas, not a solid, in the center of a star.

Answer: C

Diff: 1 Page Ref: 21.2R

- 7) A 20 solar mass star has a main sequence lifetime of 10 million years, yet its iron core exists for only about how long?

- A) less than a day
- B) about one week
- C) two months
- D) one year
- E) a hundred years

Answer: A

Diff: 2 Page Ref: 21.2R

- 8) Which of these is the likely progenitor of a type I supernova?

- A) a mass-transfer binary, with the white dwarf already at 1.3 solar masses
- B) a contact binary, with the neutron star at 2.3 solar masses
- C) an evolved red giant which is just starting to make silicon in its core
- D) an evolved blue supergiant that is about to experience the helium flash
- E) a helium-neon white dwarf

Answer: A

Diff: 2 Page Ref: 21.2R

- 9) Which of these is the likely progenitor of a type II supernova?

- A) a mass-transfer binary, with the white dwarf already at 1.3 solar masses
- B) a contact binary, with the neutron star at 2.3 solar masses
- C) an evolved red giant which is just starting to make silicon in its core
- D) two white dwarfs in a contact binary system
- E) an evolved blue supergiant that is about to experience the helium flash

Answer: C

Diff: 2 Page Ref: 21.2R

- 10) Beyond the formation of iron, nuclear energy can be produced only by:

- A) fusion of still heavier elements.
- B) ionization of the radioactive nuclei.
- C) fission of heavy nuclei back toward lighter ones.
- D) gravity.
- E) the dark force.

Answer: C

Diff: 1 Page Ref: 21.2N

- 11) Most of the energy of the supernova is carried outward via a flood of:

- A) gamma rays.
- B) helium nuclei.
- C) protons.
- D) neutrinos.
- E) positrons.

Answer: D

Diff: 2 Page Ref: 31.2N

12) In neutronization of the core, a proton and an electron make a neutron and a:

- A) positron.
- B) muon.
- C) neutrino.
- D) pion.
- E) antineutron.

Answer: C

Diff: 2 Page Ref: 21.2N

13) A temperatures of _____ K, photons can split apart nuclei until only protons and neutrons are left in photodisintegration.

- A) ten million
- B) 100 million
- C) one billion
- D) ten billion
- E) one hundred billion

Answer: D

Diff: 3 Page Ref: 21.2N

14) The production of which element in the core of a highly evolved giant leads to type II supernovae?

- A) helium
- B) neon
- C) carbon
- D) iron
- E) uranium

Answer: D

Diff: 1 Page Ref: 21.2R

15) What is the only way that a white dwarf can suddenly explode in a type I supernova?

- A) if it is a detached binary with a red supergiant
- B) if another star collides with it, such as with the blue stragglers
- C) if it passes through a large dense dust cloud
- D) if it is a member of a mass-transfer binary
- E) if it finally cools off to under 2,000 K and collapses as a black dwarf

Answer: D

Diff: 2 Page Ref: 21.3R

16) How long does it take a stellar iron core to collapse?

- A) one second
- B) one minute
- C) one year
- D) 200 years
- E) millions of years

Answer: A

Diff: 1 Page Ref: 21.3R

17) What was most surprising about SN1987A?

- A) That it did not happen in our own Galaxy.
- B) The parent star was a B supergiant, not a red supergiant.
- C) Its absolute magnitude was greater than any other observed supernova.
- D) It did not brighten again after about 80 days.
- E) It did not produce a burst of neutrinos as theory predicts.

Answer: B

Diff: 2 Page Ref: 21.3R

18) The making of abundant iron nuclei is typical of:

- A) planetary nebula ejection.
- B) the helium flash.
- C) all novae.
- D) type I supernovae.
- E) type II supernovae.

Answer: E

Diff: 2 Page Ref: 21.3R

19) Type I supernovae are NOT:

- A) products of mass transfer.
- B) created by the mass of the white dwarf exceeding Chandrasekhar's Limit.
- C) rich in hydrogen from the outer envelope of the collapsed star.
- D) brighter than type II supernovae.
- E) created by carbon detonation.

Answer: C

Diff: 2 Page Ref: 21.3N

20) What made supernova 1987a so useful to study?

- A) We saw direct evidence of nickel to iron decay in its light curve.
- B) Its progenitor had been observed previously.
- C) In the Large Magellanic Cloud, we already knew its distance.
- D) It occurred after new telescopes, such as Hubble, could observe it very closely.
- E) All of the above are correct.

Answer: E

Diff: 1 Page Ref: 21.3R

21) Where was supernova 1987a located?

- A) in the Orion Nebula, M-42
- B) in Sagittarius, near the Galactic Nucleus
- C) in our companion galaxy, the Large Magellanic Cloud
- D) in M-13, one of the closest of the evolved globular clusters
- E) near the core of M-31, the Andromeda Galaxy

Answer: C

Diff: 1 Page Ref: 21.3R

22) Which of these is least likely to happen?

- A) solar type stars producing planetary nebulae
- B) red giants exploding as type II supernova
- C) recurrent supernovae of type I
- D) red dwarfs collapsing directly to helium white dwarfs
- E) contact binaries becoming novae

Answer: C

Diff: 3 Page Ref: 21.3R

23) Which of the following does not fit a type I supernova?

- A) implosion-explosion of the core of a massive star
- B) achieving the Chandrasekhar Limit for the mass of the white dwarf
- C) a mass-transfer binary system is the progenitor
- D) hydrogen-poor spectrum
- E) light curve similar to that of a nova in shape, but far greater luminosity

Answer: A

Diff: 2 Page Ref: 21.3R

- 24) A star can be a supernova:
A) in predictable cycles of decades.
B) a few times, at unpredictable intervals.
C) only if it can fuse iron in its core.
D) before it reaches the main sequence, if it is massive enough.
E) only once.

Answer: E

Diff: 1 Page Ref: 21.3R

- 25) The supernova that formed M-1, the Crab Nebula, was observed in:
A) 1572 AD by Tycho Brahe.
B) 1604 AD by Johannes Kepler.
C) 1054 AD by Chinese and other oriental and mid eastern astronomers.
D) 1006 by observers in the southern hemisphere.
E) about 9,000 BC by all our ancestors.

Answer: C

Diff: 2 Page Ref: 21.3R

- 26) What is the amount of energy emitted in the form of neutrinos, during a supernova explosion, compared to the amount of energy radiated as electromagnetic radiation?
A) only .007 as much
B) about equal amounts
C) about twice as much
D) ten times more
E) 100 times more

Answer: E

Diff: 2 Page Ref: 21.3R

- 27) What is the total energy radiated by a supernova equal to?
A) a hundred Suns
B) a thousand Suns
C) a million Suns
D) a billion Suns
E) a trillion Suns

Answer: D

Diff: 2 Page Ref: 21.3R

- 28) What produces a type-I supernova?
A) the collapse of the core of a massive star
B) the helium flash blows apart a giant's core
C) mass transfer onto a white dwarf pushing it over 1.4 solar masses
D) a nova igniting a helium flash in its red giant companion
E) the radioactive decay of nickel 56 into cobalt 56 into iron 56

Answer: C

Diff: 2 Page Ref: 21.3R

- 29) What evidence is there that supernovae really have occurred?
A) Crab Nebula
B) supernova remnants
C) existence of heavy radioactive elements in nature
D) observations of the actual explosions
E) all of the above

Answer: E

Diff: 1 Page Ref: 21.3R

30) A recurrent nova can eventually build up to a:

- A) hypernova.
- B) black hole.
- C) type I supernova.
- D) type II supernova.
- E) pulsar.

Answer: C

Diff: 3 Page Ref: 21.3R

31) Which of these depends on a mass-transfer binary to occur?

- A) a nova
- B) a type I supernova
- C) a type II supernova
- D) Both A and B depend on mass transfer onto the white dwarf.
- E) All of these need mass transfer to achieve the Chandrasekhar Limit.

Answer: D

Diff: 2 Page Ref: 21.3R

32) Which of these is NOT true about supernovae?

- A) Type I involves carbon detonation.
- B) Type II involves formation of iron in the core.
- C) The two types are both closely related to evolution of white dwarfs.
- D) The one in 1987 in the Large Magellanic Cloud was of type II.
- E) Neutronization is vital in understanding type II core collapse.

Answer: C

Diff: 3 Page Ref: 21.3N

33) Which statement about our current knowledge of elements is FALSE?

- A) We now know of more than 110 elements, both natural and man-made.
- B) 81 stable elements have been found on Earth.
- C) 10 radioactive elements are also found on Earth.
- D) We have now produced over 50 radioactive elements not occurring in nature.
- E) Technetium is found in giant stars, but not yet in nature on the Earth.

Answer: D

Diff: 3 Page Ref: 21.4N

34) The alpha process tends to produce chiefly:

- A) only carbon.
- B) stable elements.
- C) even numbered elements.
- D) odd numbered elements.
- E) only radioactive elements.

Answer: C

Diff: 2 Page Ref: 20.4R

35) When a stellar iron core collapses, large numbers of neutrinos are formed, then:

- A) they form the neutron star.
- B) they are absorbed by electrons to produce positrons.
- C) they are captured to form heavy elements.
- D) they are captured to form light elements.
- E) they immediately pass through the core and escape to space.

Answer: E

Diff: 1 Page Ref: 21.4R

36) As seen in 1987, when two silicon 28 nuclei fuse, or when seven alpha particles are added to a Si-28 nucleus, the initial result in either case is:

- A) the shedding of bipolar planetary nebula shells.
- B) a nova explosion.
- C) iron 56.
- D) cobalt 56.
- E) nickel 56.

Answer: E

Diff: 3 Page Ref: 21.4R

37) When helium capture occurs with a carbon 12 nucleus, what results?

- A) nitrogen 14
- B) oxygen 16
- C) neon 20
- D) silicon 28
- E) nickel 56

Answer: B

Diff: 2 Page Ref: 21.4R

38) The transformation of cobalt 56 into iron 56 is an example of:

- A) neutronization.
- B) the r process rapidly adding on neutrons.
- C) the strong force and nuclear fusion.
- D) the weak force and nuclear fission creating a beta decay, with an electron given off.
- E) the s process slowly producing new isotopes.

Answer: D

Diff: 3 Page Ref: 21.4R

39) What is the reason a type-II supernova slows its dimming after about 2 months?

- A) The planetary nebula cooled enough to form a dust shell.
- B) Energy is released from the decay of radioactive cobalt 56 to iron 56.
- C) The supernova remnant suddenly becomes transparent.
- D) The burst of energy carried by neutrinos is finally observed.
- E) Energy from the supernova's shock wave is released as it hits interstellar matter.

Answer: B

Diff: 2 Page Ref: 21.4R

40) The iron we commonly find in our surroundings came from:

- A) the iron core of a massive star which exploded as a type I supernova.
- B) planetary nebulae.
- C) jets ejected by a rapidly spinning pulsar.
- D) material ejected by a nova explosion.
- E) decay of nickel 56 and cobalt 56 in a supernova remnant.

Answer: E

Diff: 2 Page Ref: 21.4R

41) As a star evolves, heavier elements tend to form by various processes. Which of the following is not one of these processes?

- A) proton capture and neutron capture
- B) fusion of like nuclei
- C) helium capture
- D) the s process
- E) neutronization

Answer: E

Diff: 2 Page Ref: 21.4R

42) Which type of heavy atomic nuclei are most common, and why?

- A) Transuranium elements, for only very heavy elements are made in supernovae.
- B) Odd numbered elements, because hydrogen is the building block for all heavier elements.
- C) Even numbered elements, for helium is "giant food" for everything beyond itself.
- D) Metals, for iron is the last abundant element formed before the type II supernova.
- E) Noble gases, for they are the most stable elements.

Answer: C

Diff: 2 Page Ref: 21.4R

43) Nearly all the elements found in nature were formed inside stars, except for:

- A) carbon and silicon.
- B) hydrogen and helium.
- C) helium and carbon.
- D) silver and technetium.
- E) uranium and radium.

Answer: B

Diff: 1 Page Ref: 21.4R

44) Why does neutron capture work?

- A) Neutrons have no repulsive barrier to overcome in combining with positively charged nuclei.
- B) Neutrinos, because of their low mass and high speed, easily penetrate nuclei.
- C) Single protons have little repulsion to heavy nuclei and easily fuse with them.
- D) Photodisintegration makes many alpha particles, available for capture by nuclei.
- E) Neutronization captures all the protons and electrons.

Answer: A

Diff: 2 Page Ref: 21.4R

45) What is stellar nucleosynthesis?

- A) The formation of heavier elements inside stars.
- B) The formation of planetary nebulae by red giants.
- C) The formation of stars from a nucleus of contracting material.
- D) The formation of white dwarfs, neutron stars, and black holes from stars.
- E) The process by which stars form interstellar dust.

Answer: A

Diff: 1 Page Ref: 21.4R

46) Of the common elements in your body, the only one not formed in stellar nucleosynthesis is:

- A) iron.
- B) calcium.
- C) hydrogen.
- D) carbon.
- E) oxygen.

Answer: C

Diff: 1 Page Ref: 21.4R

- 47) The heaviest nuclei of all are formed:
- A) by neutron capture during a type II supernova explosion.
 - B) during a nova explosion.
 - C) during a carbon detonation supernova.
 - D) during carbon burning in the giant stage.
 - E) during the triple alpha process.

Answer: A

Diff: 2 Page Ref: 21.4R

- 48) What direct evidence do astronomers have that supports the heavy element formation in stars?
- A) the presence of technetium in giant star spectra
 - B) observed elemental abundances
 - C) gamma-ray emissions from decay of cobalt 56 in supernovae
 - D) light curves of type-I supernovae
 - E) All of the above are evidence of this.

Answer: E

Diff: 2 Page Ref: 21.4R

- 49) In order of visual luminosity at the start, which is most luminous?
- A) a red supergiant
 - B) a planetary nebula
 - C) a nova
 - D) a type I supernova
 - E) a type II supernova

Answer: D

Diff: 2 Page Ref: 21.5R

- 50) Which statement about young stars is FALSE?
- A) They contain a larger fraction of heavy elements than previous generations.
 - B) They are born in a dustier environment than earlier generations.
 - C) They are more likely to have planets forming with them than earlier generations.
 - D) The high mass stars will be more likely to produce heavier elements as they evolve.
 - E) Being young, they will have more pure hydrogen than earlier generations.

Answer: E

Diff: 3 Page Ref: 21.5N

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) What would happen if mass is continually added to a 1.4 solar mass neutron star?
- A) It will erupt as a nova.
 - B) The star's radius would increase.
 - C) The star would eventually become a black hole if it exceeded 3 solar masses.
 - D) The star would erupt as a supernova.
 - E) all of the above

Answer: C

Diff: 2 Page Ref: 22.1R

- 2) What would happen if mass is added to a 1.4 solar mass white dwarf?
- A) The star would explode as a nova.
 - B) The star's radius would increase
 - C) The star would immediately collapse into a black hole
 - D) The star would erupt as a carbon detonation (type I) supernova.
 - E) The core would collapse as a type II supernova.

Answer: D

Diff: 2 Page Ref: 22.1R

- 3) The average density of neutron stars approaches:
- A) a million times that of normal matter.
 - B) a million times that of even a white dwarf.
 - C) about 10^{17} kg/m³, similar to the density of atomic nuclei.
 - D) about 10^{18} times that of water.
 - E) infinity.

Answer: C

Diff: 2 Page Ref: 22.1N

- 4) In the Lighthouse model:
- A) pulsars are observable only if they lie in the galactic plane.
 - B) pulsars are navigational devices created by interstellar navigators as discovered by Jocelyn Bell in 1967.
 - C) all pulsars have their poles pointed directly at us or they would be not observable.
 - D) if the beams sweeps across us, we can observe the pulse.
 - E) the period of pulsation must speed up as the neutron star continues contracting.

Answer: D

Diff: 2 Page Ref: 22.2R

- 5) Which of the following is not a property of the first discovered pulsar (nor any other pulsar)?
- A) period of 1.34 seconds
 - B) over time, the period is gradually increasing
 - C) emissions only in the visible part of the spectrum
 - D) each pulse consisting of a 0.01 second burst of radiation
 - E) time interval between pulses is very uniform

Answer: C

Diff: 2 Page Ref: 22.2R

- 6) The supernova of 1054 AD produced:
- A) a remnant still visible to the naked eye, the Crab Nebula, M-1.
 - B) a pulsar with a period of 33 milliseconds, visible optically.
 - C) the closest known neutron star to our Sun.
 - D) the most famous black hole.
 - E) no remaining visible trace, as it was a type I supernova.

Answer: B

Diff: 3 Page Ref: 22.2R

- 7) Who received the Nobel Prize in Physics for relating pulsars to neutron star formation?

- A) Jocelyn Bell
- B) Anthony Hewish
- C) Sir Bernard Lovell
- D) Martin Schwarzschild
- E) Stephen Hawking

Answer: B

Diff: 3 Page Ref: 22.2R

- 8) Whose work with SETI led to the discovery of pulsars in 1967?

- A) Jocelyn Bell
- B) Sir Bernard Lovell
- C) Anthony Hewish
- D) Martin Schwarzschild
- E) Stephen Hawking

Answer: A

Diff: 2 Page Ref: 22.2R

- 9) The vast majority of pulsars are known only from their pulses in:

- A) X-rays.
- B) gamma rays.
- C) visible light.
- D) microwaves.
- E) radio waves.

Answer: E

Diff: 1 Page Ref: 22.2N

- 10) What compelling evidence links pulsars to neutron stars?

- A) Both pulsars and neutron stars can be found in globular star clusters.
- B) Pulsars are known to evolve into neutron stars.
- C) Only a small, very dense source could rotate that rapidly without flying apart.
- D) Pulsars are always found in binary systems with neutron stars.
- E) Both pulsars and neutron stars have been discovered near the Sun.

Answer: C

Diff: 1 Page Ref: 22.2R

- 11) What makes the Crab pulsar somewhat unusual among pulsars in general?

- A) It is the most intense source of X-rays in the sky.
- B) It is the fastest pulsar known.
- C) It is the oldest pulsar observed.
- D) Its period is not regular like other pulsars.
- E) It is rather bright at visible wavelengths.

Answer: E

Diff: 2 Page Ref: 22.2R

12) While most neutron stars are also pulsars, an older "bare" neutron star was captured in rapid motion only 200 light years distant by:

- A) Arecibo Radio Observatory.
- B) the Keck Telescopes used as an interferometer.
- C) the Chandra X-ray observatory.
- D) the Hubble Space Telescope.
- E) the Spitzer Infrared Space Telescope.

Answer: D

Diff: 3 Page Ref: 22.2N

13) What are X-ray bursters?

- A) They are the central sources of energy for planetary nebulae.
- B) They are very massive stars that explode as supernovae, emitting bursts of X-rays and gamma-rays in the process.
- C) They are rapidly rotating black holes whose precession points their poles toward us on occasion.
- D) They are violent energy sources known to lie at the heart of the Milky Way and similar massive galaxies.
- E) They are neutron stars on which accreted matter builds up, then explodes in a violent nuclear explosion.

Answer: E

Diff: 2 Page Ref: 22.3R

14) To which of these phenomena are X-ray bursters most similar?

- A) novae
- B) planetary nebulae
- C) type I supernovae
- D) type II supernovae
- E) hypernovae

Answer: A

Diff: 2 Page Ref: 22.3N

15) Almost half of all known millisecond pulsars are found in what type of object?

- A) giant molecular clouds
- B) open clusters
- C) globular clusters
- D) emission nebulae
- E) supernova remnants

Answer: C

Diff: 2 Page Ref: 22.3R

16) Three terrestrial planetary-sized masses have been discovered orbiting:

- A) the solar type star Tau Ceti.
- B) a black hole.
- C) a white dwarf.
- D) a millisecond pulsar.
- E) a brown dwarf.

Answer: D

Diff: 2 Page Ref: 22.3R

17) X-ray bursters occur in binary star systems. The two types of stars that must be present to make up such an object are:

- A) a white dwarf and a neutron star.
- B) a contact binary system of two red giants.
- C) a white dwarf and a main sequence star.
- D) a main sequence or giant star and a neutron star in a mass transfer binary.
- E) two neutron stars in a mass transfer binary.

Answer: D

Diff: 2 Page Ref: 22.3R

18) A critical difference between millisecond and normal pulsars is that:

- A) the millisecond ones are not associated with the galaxy, but scattered everywhere.
- B) the millisecond ones are speeding up, but normal pulsars slow down over time.
- C) the millisecond ones must eventually collapse into black holes.
- D) the millisecond ones all have planets, while normal ones do not.
- E) millisecond ones are only found in globular clusters, while normal ones are not.

Answer: B

Diff: 3 Page Ref: 22.3N

19) In contrasting the distribution of the X-ray and gamma-ray bursts, we find:

- A) gamma ray bursts are far closer to us, so they appear more luminous.
- B) gamma ray bursts are far beyond our Galaxy, at cosmological distances, and spread all over the sky, not in the plane of our Galaxy.
- C) gamma ray bursts are more closely associated with open than globular clusters.
- D) gamma ray bursts can repeat, while the X-ray bursts do not.
- E) gamma ray bursts can be observed from the ground, but X-rays are blocked by the ionosphere for ground based observers.

Answer: B

Diff: 3 Page Ref: 22.4N

20) Which statement about gamma-ray bursts is NOT correct?

- A) They seem to be coming from far beyond the Milky Way, in other host galaxies.
- B) They are a scaled up versions of the repeating X-ray bursts, with more massive stars involved and longer periods as well.
- C) In seconds, they seem to radiate hundreds of times more energy than do either type of supernovae.
- D) We have found optical afterglows, with immense red shifts.
- E) Millisecond flickering implies they can be only a few hundred kilometers in size.

Answer: B

Diff: 3 Page Ref: 22.4R

21) In a "hypernova", the very energetic supernova creates a:

- A) many repeating X-ray bursts for long periods of time.
- B) very visible supernova remnant, even brighter than the Crab.
- C) black hole with focused bipolar jets from its poles.
- D) millisecond pulsar, occasionally with planets.
- E) planetary nebula, then planets themselves forming around a pulsar.

Answer: C

Diff: 2 Page Ref: 22.4R

22) Which of the following can actually escape from inside a black hole's event horizon?

- A) neutrinos
- B) electrons
- C) very high energy gamma-rays
- D) gravitons
- E) none of the above

Answer: E

Diff: 2 Page Ref: 22.5R

23) While perhaps affected by rotation and magnetism, we think the lower limit for black holes is:

- A) Kelvin's limit of 0.08 solar masses.
- B) Chandrasekhar's limit of 1.4 solar masses.
- C) Schwarzschild's limit of 3 solar masses.
- D) the high mass star limit of 8 solar masses.
- E) Einstein's limit of 25 solar masses for the main sequence stars.

Answer: C

Diff: 2 Page Ref: 25.5R

24) The Schwarzschild radius for a three solar mass black hole is:

- A) about three meters.
- B) about nine kilometers.
- C) about the size of the Earth.
- D) about the size of Jupiter.
- E) larger than our Sun.

Answer: B

Diff: 2 Page Ref: 22.5N

25) What explanation does general relativity provide for gravity?

- A) Gravity is the weakest of the four universal forces.
- B) Gravity is a result of curved spacetime.
- C) Gravity is directly proportional to mass.
- D) Gravity is inversely proportional to radius.
- E) All of the above are correct.

Answer: B

Diff: 1 Page Ref: 22.6R

26) Which of the following are attracted by gravity?

- A) antimatter
- B) any object with mass
- C) electromagnetic radiation
- D) neutrinos
- E) all of the above

Answer: E

Diff: 2 Page Ref: 22.7R

27) The observed slowing of a clock in the vicinity of a black hole is a prediction of:

- A) the Roche Limit.
- B) Special relativity.
- C) General relativity.
- D) Stellar nucleosynthesis.
- E) the Cosmological Principle.

Answer: C

Diff: 2 Page Ref: 22.7R

- 28) Which of the following is NOT an argument for Cygnus X-1's being a true black hole?
- A) Spectroscopic data suggests hot gas is flowing from the companion B star onto Cygnus X-1.
 - B) The mass of the visible B star is even greater than Cygnus X-1, at around 25 solar masses.
 - C) Cygnus X-1's mass is estimated to be about 10 solar masses.
 - D) X-rays from Cygnus X-1 vary on time scales as short as a millisecond.
 - E) X-ray observations around the object support a temperature of several million K.

Answer: B

Diff: 3 Page Ref: 22.8R

- 29) The key to identifying a black hole candidate in a binary system is that:
- A) one of the two stars cannot be seen.
 - B) the unseen companion in the system must have a sufficiently high mass.
 - C) the unseen star is a contact binary.
 - D) the system must be a very strong source of radio emissions.
 - E) the visible companion must be an evolving main sequence or giant star.

Answer: B

Diff: 2 Page Ref: 22.8R

- 30) What is the name of the most famous black hole candidate?
- A) Betelgeuse
 - B) Scorpio X-1
 - C) Cygnus X-1
 - D) Sagittarius A
 - E) Centaurus A

Answer: C

Diff: 1 Page Ref: 22.8N

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) The part of the Milky Way we are most familiar with is the:
- A) Corona.
 - B) Galactic Disk.
 - C) Halo.
 - D) Galactic Bulge.
 - E) Galactic Center.

Answer: B

Diff: 2 Page Ref: 23.1N

- 2) What perception of the Milky Way Galaxy did astronomers have in 1900?
- A) They believed that the Earth rested inside concentric spheres, with the Milky Way stars fixed to the outermost sphere.
 - B) They believed that the Milky Way was one of billions of galaxies in the universe.
 - C) They believed that the Milky Way was the entire universe.
 - D) They believed that, because the Sun was at the center of the Milky Way, it was impossible to see the rest of the universe.
 - E) They believed we were one of billions galaxies in an expanding universe.

Answer: C

Diff: 2 Page Ref: 23.2R

- 3) What is one of the differences between Cepheid variables and RR Lyrae variables?
- A) Cepheids are higher luminosity stars than RR Lyrae variables, and have longer periods.
 - B) All Cepheids have the same luminosity, while RR Lyrae stars vary greatly in brightness.
 - C) RR Lyrae variables pulsate irregularly as compared to Cepheids which are very regular.
 - D) RR Lyrae are eclipsing binaries, but Cepheids actually do pulsate.
 - E) Cepheids vary because they are mass transfer binaries; RR Lyrae variables vary because they are

pulsating single stars.

Answer: A

Diff: 2 Page Ref: 23.2R

4) Matter belonging to the Galaxy can be traced out to _____ from the center.

A) 5 kpc

B) 8 kpc

C) 15 kpc

D) 50 kpc

E) 200 kpc

Answer: D

Diff: 2 Page Ref: 23.2R

5) From the Sun, what is the distance to the Galaxy's center?

A) 3 kpc

B) 8 kpc

C) 30 kpc

D) 300 pc

E) 1,000 light years

Answer: B

Diff: 2 Page Ref: 23.2R

6) For what type of object is the period-luminosity relation used for determining distances?

- A) RR Lyrae variables
- B) T Tauri variables
- C) Cepheids
- D) Cataclysmic variables
- E) Planetary nebulae

Answer: C

Diff: 1 Page Ref: 23.2R

7) The location of the center of the Galaxy was determined by Shapley from observations of:

- A) cepheids in open clusters.
- B) RR Lyrae variables in globular clusters.
- C) Herbig-Haro objects in emission nebulae.
- D) blue supergiants in the spiral arms.
- E) the radio emissions from Sagittarius A.

Answer: B

Diff: 1 Page Ref: 23.2R

8) Which is the correct description of the Sun's location within the Milky Way?

- A) at the outer edge of the galactic bulge but in the plane of the disc
- B) in the disc but at its outer edge
- C) as Herschel found, very close to the Galactic center
- D) above the disc and about one-third of the galactic radius from the center
- E) in the disc and about one-half a galactic radius from the center

Answer: E

Diff: 2 Page Ref: 23.2R

9) For finding the distances to globular clusters, Harlow Shapley relied on what yardsticks?

- A) emission nebulae
- B) eclipsing binaries
- C) type I supernovae
- D) RR Lyrae variables
- E) planetary nebulae

Answer: D

Diff: 2 Page Ref: 23.2R

10) Which of these variable stars would be classified as a Cepheid?

- A) a K giant with a period of 14 days
- B) a G giant with a period of 14 hours
- C) a M giant with a period of 14 years
- D) a B supergiant with a period .14 days
- E) an eclipsing binary with a period of 2.3 days

Answer: A

Diff: 2 Page Ref: 23.2R

11) Which of these variable stars would be classified as a RR Lyrae variable?

- A) a B supergiant with a period .14 days
- B) a M giant with a period of 140 days
- C) a G giant with a period of 14 hours
- D) a K giant with a period of 14 days
- E) an A main sequence star rotating every 17 hours

Answer: C

Diff: 2 Page Ref: 23.2R

12) Which two classes of objects were critical to the Shapley-Curtiss Debate of 1920?

- A) white dwarfs and red giants
- B) open clusters and emission nebulae
- C) globular clusters and spiral nebulae
- D) emission nebulae and spiral nebulae
- E) planetary nebulae and white dwarfs

Answer: C

Diff: 2 Page Ref: 23.2N

13) The region on the H-R diagram where pulsating variables occur is called the:

- A) period-luminosity relation.
- B) mass-luminosity relation.
- C) instability strip.
- D) horizontal branch.
- E) main sequence appendix.

Answer: C

Diff: 2 Page Ref: 23.2N

14) The first attempt to map the Galaxy via star counts was done by:

- A) Galileo in 1612.
- B) William Herschel in the late eighteenth century.
- C) Edward Barnard with long exposure photos about 1900.
- D) Harlow Shapley with the RR Lyrae variables in 1920.
- E) Edwin Hubble with the new 100" Mt. Wilson telescope in the 1930s.

Answer: B

Diff: 3 Page Ref: 23.2N

15) Based on star counts, 100 years ago most astronomers thought:

- A) we lay about 30,000 ly out from the center of the Galaxy.
- B) we lay near the center of a disk about 10 kpc wide and 2 kpc thick.
- C) we lay in a spiral arm of the largest galaxy in the universe.
- D) we lay near the edge of the only galaxy in the universe.
- E) we were not a part of any structure larger than the known solar system.

Answer: B

Diff: 1 Page Ref: 23.2N

16) The period-luminosity relation was discovered in 1908 by:

- A) William Herschel.
- B) Henrietta Leavitt.
- C) Harlow Shapley.
- D) Heber Curtiss.
- E) Edwin Hubble.

Answer: B

Diff: 3 Page Ref: 23.2N

17) It was the distribution of _____ that showed Harlow Shapley we were no where near the center of the Milky Way in the 1920s.

- A) planetary nebulae
- B) emission nebulae
- C) open clusters
- D) globular clusters
- E) supernova remnants

Answer: D

Diff: 1 Page Ref: 23.2N

18) The man who almost singlehandedly made the Milky Way five times larger in the 1920s was:

- A) Edwin Hubble.
- B) Heber Curtiss.
- C) William Herschel.
- D) Edward Barnard.
- E) Harlow Shapley.

Answer: E

Diff: 2 Page Ref: 23.2N

19) In the Shapley-Curtiss debate in 1920, which of these is NOT true?

- A) Shapley was correct about the Milky Way being much larger than earlier thought.
- B) Curtiss correctly believed that the Milky Way was but one of many galaxies.
- C) Shapley was correct in stating that the spiral nebula observations proved they must be nearby, otherwise their rotations would exceed the speed of light.
- D) Curtiss was correct in noting that spiral nebulae did not lie close to the galactic plane because of obscuring dust in the way.
- E) Shapley was incorrect in showing novae in the spiral nebulae proved they were close, for we know know these were supernovae, not regular novae he studied.

Answer: C

Diff: 3 Page Ref: 23.2N

20) Which of the following structures is not a part of our own Milky Way Galaxy?

- A) halo
- B) nucleus
- C) disk
- D) ring
- E) spiral arms

Answer: D

Diff: 1 Page Ref: 23.3R

21) Which statement about Population I is incorrect?

- A) The bright blue stars that dominate the night sky belong to it.
- B) The Sun is one of its older members.
- C) Their orbits lie close to the plane of the Galaxy.
- D) Its stars surround the Galaxy in the extended halo.
- E) Its stars are richer in heavier elements made in supernovae.

Answer: D

Diff: 2 Page Ref: 23.3R

22) Which statement about Population II is incorrect?

- A) These older stars are richer in heavier elements they have made in their cores.
- B) Its most notable groupings are the globular star clusters.
- C) Its brightest stars are evolved red giants.
- D) They lie anywhere from the galactic nucleus out to deep into the halo.
- E) Its oldest members may be over ten billion years old.

Answer: A

Diff: 3 Page Ref: 23.3R

23) In terms of their motions and distributions, which statement is FALSE?

- A) Population I stars lie in the disc of the galaxy, with Population II out in the halo.
- B) Population I star orbits resemble planet orbits, with Population II more like comet orbits.
- C) Population II globular clusters are only found in the halo, not anywhere near the bulge or nucleus.
- D) Population I open clusters lie in the galactic plane and are comparatively young.
- E) Almost everything we see with the naked eye belongs to Population I.

Answer: C

Diff: 2 Page Ref: 23.3R

24) The "aspect ratio" of thickness to width of the galactic disk is about:

- A) 1:2.
- B) 1:5.
- C) 1:10.
- D) 1:100.
- E) 1:1,000.

Answer: D

Diff: 3 Page Ref: 23.3N

25) In the halo, we do NOT find:

- A) tidal streams.
- B) globular clusters.
- C) small satellite galaxies.
- D) spiral arms.
- E) old white dwarfs.

Answer: D

Diff: 2 Page Ref: 23.3N

26) Which sequence of formation by age is correct, oldest to youngest?

- A) dark nebulae, planetary nebulae, emission nebulae
- B) spiral arms, bulge, halo
- C) halo, spiral arms, globular clusters
- D) globular clusters, emission nebulae, open clusters
- E) Population I stars, Population II stars, Population III stars

Answer: D

Diff: 3 Page Ref: 23.4R

27) Star formation ceased first in the:

- A) nucleus.
- B) spiral arms.
- C) bulge.
- D) halo.
- E) galactic disk.

Answer: D

Diff: 1 Page Ref: 23.4N

28) Of what use are the Doppler shifts of the 21-cm radio signals?

- A) They let astronomers map the large-scale motion and distribution of gas in the Milky Way's spiral arms.
- B) They can more easily pick up the heat of brown dwarfs and dark matter.
- C) They are used to study distant stars in the Galaxy's halo and corona.
- D) They let astronomers "see" into black holes.
- E) They let astronomers learn about the process of star formation.

Answer: A

Diff: 1 Page Ref: 23.5R

29) Which of the following is not typical of the Galaxy's spiral arms?

- A) giant molecular clouds
- B) young star clusters
- C) OB associations
- D) globular clusters
- E) emission nebulae

Answer: D

Diff: 2 Page Ref: 23.5R

30) The leading explanation for the existence of spiral arms are:

- A) shock waves from cyclic supernovae explosions.
- B) shock wave from the quasar-like eruption of the galactic core.
- C) passages of spiral density waves through the interstellar medium.
- D) passages of massive globular clusters through the galactic plane.
- E) tidal streams of small galaxies being torn up by our monster Galaxy.

Answer: C

Diff: 2 Page Ref: 23.5N

31) What two observations of an object allow for a determination of the Milky Way's mass?

- A) object's age and chemical composition
- B) object's mass and velocity
- C) object's age and distance from Galactic Center
- D) object's mass and age
- E) object's velocity and distance from the galactic center

Answer: E

Diff: 2 Page Ref: 23.6R

32) The Galactic Year, for our Sun to orbit our Galaxy, is about:

- A) 26,000 years.
- B) 65 million years.
- C) 225 million years.
- D) 4.5 billion years.
- E) 11 billion years.

Answer: C

Diff: 2 Page Ref: 23.6N

33) Using an orbit size of 8 kpc, and a period of 225 million years, the mass of our Galaxy is found to be close to:

- A) 10^6
- B) 10^8
- C) 10^{10}
- D) 10^{11}
- E) 10^{12}

Answer: D

Diff: 3 Page Ref: 23.6N

34) What observation of the Galaxy suggests it is much larger than the halo and contains a large amount of matter not in the form of stars?

- A) tidal streams in the halo
- B) the rotation curve
- C) motions of the globular clusters
- D) the shape of the spiral arms
- E) infrared observations of the center of the Galaxy

Answer: B

Diff: 1 Page Ref: 23.6R

35) Not now considered a good explanation for the dark matter in the halo is:

- A) WIMPs.
- B) MACHOs.
- C) black holes.
- D) clouds of cool, neutral hydrogen.
- E) brown dwarfs.

Answer: D

Diff: 2 Page Ref: 23.6N

36) The rotation curve reveals:

- A) there is more mass beyond our orbit than inside it in our Galaxy.
- B) the stars beyond us are moving faster than Kepler would have expected.
- C) the luminosity distribution drops off more sharply than does the mass distribution.
- D) there is a dark halo far beyond the faintly visible one.
- E) All of the above are correct.

Answer: E

Diff: 2 Page Ref: 23.6N

37) While yet unproven, the proposed WIMPS would be:

- A) massive like neutrons, but more elusive than neutrinos.
- B) made of only strong magnetic fields.
- C) rapidly decaying due to the weak nuclear force.
- D) changing charges and polarities too rapidly to pin down.
- E) the basic building blocks of neutrons and protons.

Answer: A

Diff: 3 Page Ref: 23.6N

38) Which of these techniques has the most promise for detecting MACHOs?

- A) tracking down their tidal streams in the halo
- B) detecting the X-rays emitted as they trap interstellar matter
- C) observing duration and intensity of gravitational lenses
- D) observing duration of their eclipses of normal companions
- E) seeing transits as they pass in front of background stars' disks

Answer: C

Diff: 2 Page Ref: 23.6N

39) As found by radio astronomers, the core of our Galaxy is known as:

- A) Globular Central.
- B) Cygnus X-1.
- C) Sagittarius A.
- D) Centaurus A.
- E) SS 443.

Answer: C

Diff: 1 Page Ref: 23.7N

40) The object located at the center of the Galaxy is believed to be:

- A) a large cluster of very young and massive stars.
- B) an enormous emission nebula.
- C) a black hole of over 3 million solar masses.
- D) a quasar of over a billion solar masses.
- E) a hypernova about to happen...be very afraid.

Answer: C

Diff: 1 Page Ref: 23.7R

TRUE/FALSE. Write 'T' if the statement is true and 'F' if the statement is false.

1) The Milky Way is simply our edge-on view of our home Galaxy.

Answer: TRUE

Diff: 1 Page Ref: 23.1N

2) A pulsating variable star with a period of 10 days would be a Cepheid.

Answer: TRUE

Diff: 2 Page Ref: 23.2

3) The instability strip includes many main sequence stars.

Answer: FALSE

Diff: 2 Page Ref: 23.2N

4) Henrietta Leavitt first showed the relationship between the mass and luminosity of Cepheids and their period of pulsation; the brighter, the longer this period.

Answer: TRUE

Diff: 2 Page Ref: 23.2N

5) It was Harlow Shapley who used the RR Lyrae variables in open clusters to first get the real measure of our Galaxy.

Answer: FALSE

Diff: 3 Page Ref: 23.2N

6) RR Lyrae stars also pulsate, but with shorter periods and lower luminosities than do Cepheids.

Answer: TRUE

Diff: 2 Page Ref: 23.2R

7) Because of their greater luminosity, RR Lyrae variable stars are useful at greater distances than are Cepheid variables.

Answer: FALSE

Diff: 2 Page Ref: 23.2

8) Cepheids are good examples of cataclysmic variable stars.

Answer: FALSE

Diff: 1 Page Ref: 23.2

9) Shapley found the Sun is located about half way out the disc from the center of the disk of the Galaxy.

Answer: TRUE

Diff: 2 Page Ref: 23.2R

10) Shapley found that globular clusters are only found in the Galactic bulge.

Answer: FALSE

Diff: 1 Page Ref: 23.2

11) In their debate, Shapley and Curtiss were especially concerned with the nature and distribution of globular star clusters and spiral nebulae.

Answer: TRUE

Diff: 2 Page Ref: 23.2N

12) As Curtiss thought, our Milky Way is now known to be quite similar to the nearby Andromeda Galaxy, M-31.

Answer: TRUE

Diff: 2 Page Ref: 23.2R

13) A critical distance mistake that Shapley made was assuming the "novae" he saw in the spiral nebulae were like the novae near us in the Milky Way; in truth, we now know they were much more luminous supernovae instead.

Answer: TRUE

Diff: 2 Page Ref: 23.2N

14) Shapley had the correct answer for the lack of spiral nebulae near the plane of our Galaxy.

Answer: FALSE

Diff: 1 Page Ref: 23.2N

15) Curtiss realized that there must be much undetected dark and obscuring matter in the plane of the Galaxy.

Answer: TRUE

Diff: 2 Page Ref: 23.2N

16) Shapley correctly argued that the rotation of the spiral nebulae proved they could not be very distant.

Answer: FALSE

Diff: 2 Page Ref: 23.2N

17) A red emission nebula, such as M-42 in Orion, is considered a Population I object.

Answer: TRUE

Diff: 2 Page Ref: 23.3R

18) The orbits of population II stars and globular clusters remind us of comets around the Sun.

Answer: TRUE

Diff: 2 Page Ref: 23.3

19) Arcturus, an orange giant with few metals, moves almost perpendicular to the galactic plane; it is the most obvious population II star in the local sky.

Answer: TRUE

Diff: 2 Page Ref: 23.3N

20) The two stellar populations are extremes, but stars with intermediate properties, like our own Sun, are very abundant.

Answer: TRUE

Diff: 2 Page Ref: 23.3R

21) Halo stars and globular clusters are all Population II objects.

Answer: TRUE

Diff: 2 Page Ref: 23.3R

22) Population I stars came billions of years before Population II stars.

Answer: FALSE

Diff: 1 Page Ref: 23.3

23) In our vicinity, the galactic disk is about 100 times wider than thick.

Answer: TRUE

Diff: 2 Page Ref: 23.3N

24) The analogy of comet-like orbits for globular clusters is reinforced by detection of tidal streams in the halo, much like the meteor shower swarms in our solar system.

Answer: TRUE

Diff: 1 Page Ref: 23.3N

25) The Sun's orbit of the Galactic Center is planetary, staying close to the galactic disc and almost circular in shape, but now the revolution takes about 225 million years.

Answer: TRUE

Diff: 2 Page Ref: 23.3R

26) Forming first, the galactic halo contains only old stars, but the disk formed later and so contains a variety of ages.

Answer: TRUE

Diff: 2 Page Ref: 23.4R

27) As the Galaxy evolved, it became flatter with rotation and time.

Answer: TRUE

Diff: 1 Page Ref: 23.4N

28) It is harder to map the structure of the Milky Way as a whole in visible light than with any other form of electromagnetic radiation.

Answer: TRUE

Diff: 2 Page Ref: 23.5

29) 21-cm radiation is an excellent way to be able to map the opposite side of the Galaxy.

Answer: TRUE

Diff: 1 Page Ref: 23.5

30) Spiral arms are regions of star formation, which accounts for their blue color.

Answer: TRUE

Diff: 1 Page Ref: 23.5

31) The spiral density wave is a favored theory for explaining the abundance and persistence of spiral arms in galaxies.

Answer: TRUE

Diff: 1 Page Ref: 23.5N

32) The exact origin of spiral structure in many galaxies is still a mystery.

Answer: TRUE

Diff: 1 Page Ref: 23.5N

33) In the spiral arms, luminous matter is obvious, but dark matter dominates the halo.

Answer: TRUE

Diff: 2 Page Ref: 23.6

34) The rotation curve for our Galaxy shows stars beyond the Sun moving slower than expected.

Answer: FALSE

Diff: 1 Page Ref: 23.6

35) The mass of the galaxy is obtained by studying its gravity curve.

Answer: FALSE

Diff: 2 Page Ref: 23.6

36) Most of the dark matter of the Galaxy is located in its disk and central bulge.

Answer: FALSE

Diff: 1 Page Ref: 23.6

37) The majority of the mass of the Milky Way lies farther out than the Sun's orbit.

Answer: TRUE

Diff: 1 Page Ref: 23.6

38) Gravitational lensing is an ideal way of detecting WIMPs.

Answer: FALSE

Diff: 2 Page Ref: 23.6N

39) The core of the Milky Way, Sagittarius A, is the strongest radio source in the sky.

Answer: TRUE

Diff: 1 Page Ref: 23.7R

40) Motions of objects near our Galaxy's core suggests the central black hole is about 3.7 billion solar masses.

Answer: FALSE

Diff: 2 Page Ref: 23.7N

TRUE/FALSE. Write 'T' if the statement is true and 'F' if the statement is false.

1) The density of a neutron star is comparable to the density of an atomic nucleus.

Answer: TRUE

Diff: 2 Page Ref: 22.1

2) In a white dwarf, the density of a million times that of normal matter is achieved by the crushing of the electron orbitals around the nucleus.

Answer: TRUE

Diff: 2 Page Ref: 22.1

3) In a neutron star, the density of the atomic nucleus is achieved by fusing the electrons and protons together, leaving nothing but neutrons in their place.

Answer: TRUE

Diff: 2 Page Ref: 22.1

4) Stars of less than 8 solar masses will produce white dwarfs when their cores collapse.

Answer: TRUE

Diff: 2 Page Ref: 22.1

5) Stars between 8 and 25 solar masses will produce neutron stars when they collapse.

Answer: TRUE

Diff: 2 Page Ref: 22.1

6) Neutron stars are the products of only type II supernovae.

Answer: TRUE

Diff: 2 Page Ref: 22.1N

7) White dwarfs are the progenitors and products of type I supernovae.

Answer: FALSE

Diff: 2 Page Ref: 22.1N

8) Only neutrinos can go faster than the speed of light, as proved by Supernova 1987A.

Answer: FALSE

Diff: 1 Page Ref: 22.2

9) Newly formed neutron stars have weak magnetic fields which strengthen over time, due to the conservation of angular momentum.

Answer: FALSE

Diff: 1 Page Ref: 22.2R

10) Most pulsars emit their pulses only in the form of radio radiation, but some are visible, or even gamma ray sources.

Answer: TRUE

Diff: 2 Page Ref: 22.2

11) Jocelyn Bell discovered pulsars, but her advisor Anthony Hewish got the Nobel Prize for relating them to neutron stars.

Answer: TRUE

Diff: 2 Page Ref: 22.2R

12) We presently know of only a few dozen rapidly spinning neutron stars observable as pulsars, for these objects quickly slow down and stop pulsing.

Answer: FALSE

Diff: 2 Page Ref: 22.2N

13) The lighthouse model for pulsars compares their focused beams, directed by their strong magnetic fields, to the sweeping beams atop a lighthouse.

Answer: TRUE

Diff: 1 Page Ref: 22.2N

14) Like most pulsars, the Crab Nebula neutron star is known only by its radio pulses.

Answer: FALSE

Diff: 2 Page Ref: 22.2N

15) Chandra images of the Crab pulsar reveal bipolar jets, much like we saw earlier with the Herbig-Haro objects expelled by protostars.

Answer: TRUE

Diff: 2 Page Ref: 22.2N

16) Neutron stars seem to travel a good deal faster than most stars in orbit about the Galaxy.

Answer: TRUE

Diff: 2 Page Ref: 22.2N

17) All neutron stars are pulsars, but not all pulsars are neutron stars.

Answer: FALSE

Diff: 2 Page Ref: 22.2N

18) All neutron stars yet detected are pulsars, for a star collapsed to the size of a city will be beyond even the ability of the Hubble Space Telescope to detect unless its strong magnetic field makes it noticeable.

Answer: FALSE

Diff: 3 Page Ref: 22.2N

- 19) X-ray bursters are similar to novae, except the collapsed star is a neutron star, not a white dwarf.
Answer: TRUE
Diff: 2 Page Ref: 22.3
- 20) If the rate at which a pulsar is slowing down is found, this helps us find the time at which it was produced by the supernova.
Answer: TRUE
Diff: 2 Page Ref: 22.3
- 21) A system of terrestrial-sized planets has been detected in orbit around a millisecond pulsar.
Answer: TRUE
Diff: 2 Page Ref: 22.3R
- 22) Millisecond pulsars seem to be associated with mass-transfer binary systems where the added mass can add to their spin energy.
Answer: TRUE
Diff: 2 Page Ref: 22.3R
- 23) All neutron stars must begin as millisecond pulsars just after their supernova creation.
Answer: FALSE
Diff: 1 Page Ref: 22.3R
- 24) SS 433 is a spectacular example of both bipolar jets and precession, as it wobbles in space with a period of 164 days.
Answer: TRUE
Diff: 2 Page Ref: 22.3N
- 25) Many millisecond pulsars lie in globular clusters, proving they cannot all be very young objects.
Answer: TRUE
Diff: 2 Page Ref: 22.3N
- 26) As of 2004, the only terrestrial type extrasolar planets have been found orbiting a millisecond pulsar.
Answer: TRUE
Diff: 2 Page Ref: 22.3N
- 27) Gamma-ray bursts come randomly from every direction in space, showing no preference for the Milky Way's galactic plane; the sources of these outbursts must lie far beyond our Galaxy.
Answer: TRUE
Diff: 2 Page Ref: 22.4R
- 28) Gamma-ray bursts seem to come primarily from neutron star binaries in the plane of our own Milky Way Galaxy.
Answer: FALSE
Diff: 2 Page Ref: 22.4
- 29) X-ray bursts and gamma ray bursts have the same distribution pattern in the sky.
Answer: FALSE
Diff: 1 Page Ref: 22.4N
- 30) A hypernova is a gamma ray burst that results in formation of a black hole, with very focused bipolar jets.
Answer: TRUE
Diff: 2 Page Ref: 22.4R

31) In a hypernova, only a tiny fraction of the universe will be in line with the bipolar jets and see the gamma rays intensely; the rest will see less energetic X-rays or even a normal appearing supernova viewed from the side.

Answer: TRUE

Diff: 2 Page Ref: 22.4N

32) In a gamma-ray burst, the term "relativistic fireball" refers to the speed of the particles ejected.

Answer: TRUE

Diff: 1 Page Ref: 22.4N

33) Besides direct formation of a black hole in a hypernova, some think that mergers between neutron stars can create even longer-lived gamma ray bursts as well.

Answer: FALSE

Diff: 3 Page Ref: 22.4N

34) Any main sequence star over 25 solar masses will probably retain enough matter in its core after its type II supernova to make a black hole.

Answer: TRUE

Diff: 2 Page Ref: 22.5N

35) The Schwarzschild radius of a black hole is about 3 km per solar mass; it is amazingly linear over a wide range of masses.

Answer: TRUE

Diff: 2 Page Ref: 22.5R

36) The escape speed for a black hole's event horizon is the speed of light.

Answer: TRUE

Diff: 1 Page Ref: 22.5R

37) In a neutron star, the Schwarzschild radius is smaller than the object's size, but as mass is added, the Schwarzschild radius grows to swallow the object and at three solar masses, the object must become a black hole.

Answer: TRUE

Diff: 2 Page Ref: 22.5N

38) The presently known laws of physics break down inside an event horizon.

Answer: TRUE

Diff: 1 Page Ref: 22.6

39) Special relativity says that c , the speed of light, is the maximum velocity for both matter and energy in our universe.

Answer: TRUE

Diff: 1 Page Ref: 22.6N

40) General relativity holds that just as there is a limit to the speed of light, there is also a single, universal frame for time as well.

Answer: FALSE

Diff: 1 Page Ref: 22.6N

41) In a black hole, space-time curves back upon itself.

Answer: TRUE

Diff: 2 Page Ref: 22.6N

42) A beam of light can go into orbit around a black hole anywhere inside its event horizon.

Answer: FALSE

Diff: 2 Page Ref: 22.6

43) Only high energy gamma-rays can escape from a black hole.

Answer: FALSE

Diff: 1 Page Ref: 22.7

44) The energy from the accretion disk around a black hole would show gravitational red shift due to its immense gravity and tidal distortion of space there.

Answer: TRUE

Diff: 2 Page Ref: 22.7N

45) Because of their size, black holes move through interstellar space and consume large quantities of matter.

Answer: FALSE

Diff: 1 Page Ref: 22.7

46) At the event horizon, time stops.

Answer: TRUE

Diff: 1 Page Ref: 22.7N

47) The principle of cosmic censorship protects us from being flashed by naked black holes.

Answer: TRUE

Diff: 2 Page Ref: 22.7N

48) The first good stellar mass black hole candidate was Cygnus X-1, the third strongest source of X-rays in the sky.

Answer: TRUE

Diff: 1 Page Ref: 22.8N

49) Very rapid time variations help establish the tiny size of many X-ray sources, showing they must be collapsed objects of some kind.

Answer: TRUE

Diff: 2 Page Ref: 22.8N

50) Stephen Hawking's work shows that black holes cannot exist above a mass limit of a few hundred solar masses.

Answer: FALSE

Diff: 1 Page Ref: 22.8N

TRUE/FALSE. Write 'T' if the statement is true and 'F' if the statement is false.

1) Novae always occur in a close binary star system.

Answer: TRUE

Diff: 1 Page Ref: 21.1

2) Because they all involve white dwarfs and companions, all novae are equally luminous.

Answer: FALSE

Diff: 2 Page Ref: 21.1

3) Unlike supernovae, novae can explode more than once, increasing their luminosity by thousands of

times.

Answer: TRUE

Diff: 1 Page Ref: 21.1N

4) It takes less and less time to fuse heavier and heavier elements inside a high mass star.

Answer: TRUE

Diff: 1 Page Ref: 21.2

5) Low mass stars must eventually collapse to white dwarfs.

Answer: TRUE

Diff: 1 Page Ref: 21.2N

6) Iron is the most stably bonded atomic nucleus.

Answer: TRUE

Diff: 1 Page Ref: 21.2N

7) Photodisintegration breaks up complex nuclei into only neutrons and protons.

Answer: TRUE

Diff: 2 Page Ref: 21.2N

8) The immense density of neutron stars comes from neutronization, where the protons and electrons are fused, and their charges cancelled.

Answer: TRUE

Diff: 2 Page Ref: 21.2N

9) In neutronization, a neutrino is also released, helping create the supernova explosion.

Answer: TRUE

Diff: 2 Page Ref: 21.2N

10) Neutronization is a critical part of the core-collapse type of supernova.

Answer: TRUE

Diff: 2 Page Ref: 21.2N

11) Because they all involve formation of iron in cores of massive stars, all type II supernovae are equally luminous.

Answer: FALSE

Diff: 2 Page Ref: 21.3

12) Because they all involve the detonation of a carbon-rich white dwarf at Chandrasekhar's limit, all type I supernovae are equally luminous.

Answer: TRUE

Diff: 2 Page Ref: 21.3

13) Novae are more closely related to type II than to type I supernovae.

Answer: FALSE

Diff: 2 Page Ref: 21.3

14) A carbon-detonation supernova starts out as a white dwarf in a close binary system.

Answer: TRUE

Diff: 2 Page Ref: 21.3

15) A recurring nova could eventually explode as a Type I supernova.

Answer: TRUE

Diff: 3 Page Ref: 21.3

- 16) The final core collapse of a massive star takes about 13 seconds.
Answer: FALSE
Diff: 2 Page Ref: 21.3
- 17) Type II supernovae have little hydrogen in their spectra; it had been used up already.
Answer: FALSE
Diff: 2 Page Ref: 21.3
- 18) A Type I supernova involves the collapsing core of a high mass star.
Answer: FALSE
Diff: 1 Page Ref: 21.3
- 19) Most of the energy released during a supernova is emitted as neutrinos.
Answer: TRUE
Diff: 2 Page Ref: 21.3
- 20) Helium capture is another name for the alpha process.
Answer: TRUE
Diff: 1 Page Ref: 21.4
- 21) The r-process occurs only during the first minutes of a supernova explosion.
Answer: TRUE
Diff: 2 Page Ref: 21.4
- 22) Helium capture is responsible for changing carbon 12 into nitrogen 14.
Answer: FALSE
Diff: 2 Page Ref: 21.4
- 23) A massive star can fuse only up to the element silicon in its core.
Answer: FALSE
Diff: 1 Page Ref: 21.4
- 24) To start the core collapse, Si-28 and alpha particles nuclei fuse first to Ni-56, which then decays, with its fission energy adding to the supernova's brightness.
Answer: TRUE
Diff: 3 Page Ref: 21.4N
- 25) If you are willing to pay the huge energy bill, you can make iron into gold.
Answer: TRUE
Diff: 2 Page Ref: 21.4R
- 26) Iron nuclei are the most tightly bound nuclei, which is why their production leads to type II supernovae.
Answer: TRUE
Diff: 2 Page Ref: 21.4R
- 27) Once carbon is formed in massive star cores, the majority of nuclei formed from then on will belong to even numbered elements, due to addition to more helium nuclei as alpha particles.
Answer: TRUE
Diff: 2 Page Ref: 21.4R
- 28) Adding an alpha particle to carbon 12 can transform it into oxygen 16 in massive stars.
Answer: TRUE
Diff: 2 Page Ref: 21.4

29) The s-process neutron-capture occurs only during a supernova explosion.

Answer: FALSE

Diff: 2 Page Ref: 21.4

30) The presence of short lived Technetium in the spectra of giant stars is evidence for the s process working inside them.

Answer: TRUE

Diff: 3 Page Ref: 21.4N

31) Stellar nucleosynthesis is responsible for the existence of all elements except hydrogen.

Answer: FALSE

Diff: 2 Page Ref: 21.4

32) Except for hydrogen and most of the helium, all the elements have been formed through stellar nucleosynthesis.

Answer: TRUE

Diff: 1 Page Ref: 21.4

33) Two isotopes of the same element differ only in the number of protons.

Answer: FALSE

Diff: 1 Page Ref: 21.4

34) Adding an alpha particle to U 235 can transform it into U 239.

Answer: FALSE

Diff: 2 Page Ref: 21.4

35) The spectra of the youngest stars shows the most heavy elements present.

Answer: TRUE

Diff: 2 Page Ref: 21.5N

TRUE/FALSE. Write 'T' if the statement is true and 'F' if the statement is false.

1) The nearest star to our Sun, Alpha Centauri, is still over a parsec distant.

Answer: TRUE

Diff: 1 Page Ref: 17.1

2) Hipparcos data on parallaxes is useful for stellar distances out to about 200 pc.

Answer: TRUE

Diff: 2 Page Ref: 17.1

3) The proper motion of a star is its true velocity through space.

Answer: FALSE

Diff: 1 Page Ref: 17.1

4) The proper motion of a star, its distance, and Doppler shift can give us its space velocity.

Answer: TRUE

Diff: 2 Page Ref: 17.1

5) Star A and star B have the same apparent magnitude. Star A is twice as distant as star B. Therefore, star A has twice the luminosity as star B.

Answer: FALSE

Diff: 3 Page Ref: 17.2

6) A magnitude 2 star is 100 times as bright as a magnitude 12 star.

Answer: FALSE

Diff: 2 Page Ref: 17.2

7) At apparent magnitude -3, Jupiter is 100X brighter than second magnitude Polaris.

Answer: TRUE

Diff: 2 Page Ref: 17.2N

8) Arcturus is absolute magnitude 0, so it is about 100X more luminous than our Sun.

Answer: TRUE

Diff: 3 Page Ref: 17.2N

9) If a star were moved 10X farther away, its absolute magnitude would drop five magnitudes.

Answer: FALSE

Diff: 3 Page Ref: 17.2N

10) If a star were moved 10X farther away, its apparent magnitude would drop by five magnitudes.

Answer: TRUE

Diff: 3 Page Ref: 17.2N

11) First magnitude Spica appears 2.5X brighter than second magnitude Polaris.

Answer: TRUE

Diff: 2 Page Ref: 17.2N

12) Hydrogen lines are weaker in both very hot and very cool stars.

Answer: TRUE

Diff: 2 Page Ref: 17.3

13) A type B9 star is hotter than a type A0.

Answer: TRUE

Diff: 1 Page Ref: 17.3

14) All else being equal, the hotter a star is, the brighter it will be.

Answer: TRUE

Diff: 1 Page Ref: 17.3

15) A G2 star is cooler than a G3.

Answer: FALSE

Diff: 1 Page Ref: 17.3

16) The spectral type of a star tells us the star's mass and luminosity.

Answer: FALSE

Diff: 1 Page Ref: 17.3

17) The Sun's spectral type is G2.

Answer: TRUE

Diff: 1 Page Ref: 17.3

18) In type O stars, ionized helium lines are more notable than in any other class.

Answer: TRUE

Diff: 2 Page Ref: 17.3

19) In type B stars, we see neutral but not ionized lines of helium in their spectra.

Answer: TRUE

Diff: 2 Page Ref: 17.3

20) M type stars usually have some molecular lines, such as TiO, well in their spectra.

Answer: TRUE

Diff: 2 Page Ref: 17.3

21) In general, the cooler the star, the more different elements show up in its spectra.

Answer: TRUE

Diff: 2 Page Ref: 17.3N

22) On the main sequence, almost all stars have radii between about 0.1 and 10 times the Sun.

Answer: TRUE

Diff: 3 Page Ref: 17.4

23) When describing the properties of stars, solar units of mass and radius are often used.

Answer: TRUE

Diff: 1 Page Ref: 17.4

24) A star of the Sun's diameter, but twice as hot, must be 16X more luminous than the Sun.

Answer: TRUE

Diff: 3 Page Ref: 17.4

25) For a few of the largest stars, direct measurements of their disks are possible.

Answer: TRUE

Diff: 2 Page Ref: 17.4N

26) If a G giant star is ten times the Sun's diameter, it will be about 100X as luminous as the Sun.

Answer: TRUE

Diff: 2 Page Ref: 17.4N

27) White dwarfs are about as big as our Earth.

Answer: TRUE

Diff: 1 Page Ref: 17.4N

28) The largest supergiants, like Betelgeuse, are about ten times larger than the Sun.

Answer: FALSE

Diff: 1 Page Ref: 17.4N

29) The vast majority of stars near us would fall to the bottom right on the H-R diagram.

Answer: TRUE

Diff: 3 Page Ref: 17.5

30) Most bright naked eye stars would lie to the top right on the H-R diagram.

Answer: FALSE

Diff: 2 Page Ref: 17.5

31) Like the Sun, main sequence stars are converting hydrogen into helium in their cores.

Answer: TRUE

Diff: 2 Page Ref: 17.5

32) On the entire H-R diagram, almost all stars are between .1 and ten solar radii in size.

Answer: FALSE

Diff: 2 Page Ref: 17.5

- 33) The Sun lies about in the center of the H-R diagram.
Answer: TRUE
Diff: 2 Page Ref: 17.5
- 34) The main sequence runs from the top left to bottom right on the H-R diagram.
Answer: TRUE
Diff: 2 Page Ref: 17.5
- 35) White dwarfs lie in the lower right part of the H-R diagram.
Answer: FALSE
Diff: 2 Page Ref: 17.5
- 36) Spectroscopic parallaxes are more accurate than trigonometric ones, but can be used only for the closest and brightest of stars.
Answer: FALSE
Diff: 2 Page Ref: 17.6N
- 37) The Sun's complete classification is G2V.
Answer: TRUE
Diff: 1 Page Ref: 17.6N
- 38) A huge supergiant, Betelgeuse is classified as a M2V.
Answer: FALSE
Diff: 2 Page Ref: 17.6N
- 39) Sirius is hotter than our Sun but still on the main sequence; it's classification is A1V.
Answer: TRUE
Diff: 2 Page Ref: 17.6N
- 40) There are a lot more M2V stars than M2Ib stars.
Answer: TRUE
Diff: 2 Page Ref: 17.6N
- 41) For a K2II star, its spectral lines will be broader than for a K2V star.
Answer: FALSE
Diff: 2 Page Ref: 17.6N
- 42) For luminosity classification, fat stars have skinny spectral lines.
Answer: TRUE
Diff: 1 Page Ref: 17.6N
- 43) It is easy to measure the mass of single stars.
Answer: FALSE
Diff: 1 Page Ref: 17.7N
- 44) Almost all our knowledge of stellar masses comes from studies of binaries.
Answer: TRUE
Diff: 1 Page Ref: 17.7N
- 45) Eclipsing binaries are the most useful, giving us sizes as well as masses of the pair.
Answer: TRUE
Diff: 2 Page Ref: 17.7N

46) In a spectroscopic binary, the star whose lines shift the most weighs the most.

Answer: FALSE

Diff: 1 Page Ref: 17.7N

47) In a binary system, the more massive stars always stay closer to the center of mass and move slower.

Answer: TRUE

Diff: 2 Page Ref: 17.7N

48) Type O and B stars never remain on the main sequence as stable stars for a billion years.

Answer: TRUE

Diff: 2 Page Ref: 17.8

49) The luminosity of a star is about equal to the fourth power of its mass.

Answer: TRUE

Diff: 2 Page Ref: 17.8N

50) A star of ten solar masses would probably stay stable on the main sequence only about 1/1,000th as long as our Sun.

Answer: TRUE

Diff: 3 Page Ref: 17.8N

TRUE/FALSE. Write 'T' if the statement is true and 'F' if the statement is false.

1) It takes about 10^{32} hydrogen atoms to make a star.

Answer: FALSE

Diff: 2 Page Ref: 19.1

2) Many of the brightest stars we see are only a few million years old.

Answer: TRUE

Diff: 2 Page Ref: 19.1N

3) The birth of stars is a battle between gravity and radiation pressure.

Answer: TRUE

Diff: 1 Page Ref: 19.1N

4) If a star is spinning rapidly, this may limit its final mass.

Answer: TRUE

Diff: 2 Page Ref: 19.1N

5) Rotation and magnetism both play key roles in protostar formation.

Answer: TRUE

Diff: 2 Page Ref: 19.1N

6) Stars evolve to the upper left along the main sequence, after forming in the middle.

Answer: FALSE

Diff: 1 Page Ref: 19.2R

- 7) A stage 4 protostar may temporarily be thousands of times more luminous than the Sun.
Answer: TRUE
Diff: 2 Page Ref: 19.2
- 8) As a protostar evolves from stage 4 to stage 6, it gets hotter but much less bright.
Answer: TRUE
Diff: 2 Page Ref: 19.2
- 9) At the end of the Kelvin-Helmholtz contraction a star is hundreds of times brighter than it will be as a main sequence star.
Answer: TRUE
Diff: 2 Page Ref: 19.2
- 10) The evolution of a star slows significantly as it approaches the main sequence.
Answer: TRUE
Diff: 2 Page Ref: 19.2
- 11) A H-R diagram of all stars should find the vast majority to the bottom right.
Answer: TRUE
Diff: 1 Page Ref: 19.3
- 12) A protostar of 20 solar masses should form a star that will stay on the main sequence twenty times longer than our Sun.
Answer: FALSE
Diff: 2 Page Ref: 19.3
- 13) Brown dwarfs are failed stars, never igniting their hydrogen fusion.
Answer: TRUE
Diff: 1 Page Ref: 19.3R
- 14) A protostar of 20 solar masses will probably turn into a type O main sequence star.
Answer: TRUE
Diff: 2 Page Ref: 19.3
- 15) Type M stars evolve to the main sequence faster than our G type Sun.
Answer: FALSE
Diff: 1 Page Ref: 19.3
- 16) Massive stars may form quickly, but last a lot longer on the main sequence than does our sun.
Answer: FALSE
Diff: 2 Page Ref: 19.3
- 17) A star spends much more time on the main sequence than it spends forming initially.
Answer: TRUE
Diff: 1 Page Ref: 19.3
- 18) Jupiter is considered to be a brown dwarf, since it does glow dull red.
Answer: FALSE
Diff: 2 Page Ref: 19.3R
- 19) For every O or B star formed, hundreds of G, K, and M stars are formed.
Answer: TRUE
Diff: 2 Page Ref: 19.3

20) T-Tauri variables are often found with Herbig-Haro objects near their poles and dusty disks around their equators.

Answer: TRUE

Diff: 2 Page Ref: 19.4R

21) Rotation of the protostar helps generate the magnetic fields and bipolar flows.

Answer: TRUE

Diff: 1 Page Ref: 19.4

22) Rotation causes the cocoon of dust to flatten into a dusty disk around protostars.

Answer: TRUE

Diff: 1 Page Ref: 19.4

23) Rotation enhances the collapse of a gas cloud in star formation, causing it to grow more massive.

Answer: FALSE

Diff: 1 Page Ref: 19.4R

24) Magnetic fields enhance the collapse of a gas cloud in star formation with bipolar flows.

Answer: FALSE

Diff: 2 Page Ref: 19.4

25) Strong stellar winds from hot O and B stars can blow away an emission nebula.

Answer: TRUE

Diff: 2 Page Ref: 19.4

26) Shock waves from exploding K and M main sequence stars can trigger further star formation.

Answer: FALSE

Diff: 2 Page Ref: 19.4

27) Shock waves from supernovae disrupt an interstellar cloud and prevent it from forming stars.

Answer: FALSE

Diff: 2 Page Ref: 19.5

28) Collisions between galaxies tend to destroy, not create, stars.

Answer: FALSE

Diff: 1 Page Ref: 19.5N

29) Most stars are usually formed singularly or as binaries, not in clusters.

Answer: FALSE

Diff: 2 Page Ref: 19.6

30) A young star cluster will be dominated by massive, bright blue main sequence stars.

Answer: TRUE

Diff: 1 Page Ref: 19.6

31) Young open clusters appear blue in color.

Answer: TRUE

Diff: 1 Page Ref: 19.6N

32) The brightest stars in globular clusters are blue supergiants.

Answer: FALSE

Diff: 2 Page Ref: 19.6N

33) In a star cluster, all members are about the same age and initial composition.

Answer: TRUE

Diff: 1 Page Ref: 19.6N

34) Most globular clusters are older than our Sun, with open clusters usually younger.

Answer: TRUE

Diff: 2 Page Ref: 19.6N

35) Our own Sun was once part of an open cluster, but as open clusters are loosely bound, our star left its parent cluster long ago; the entire cluster may have broken up by the present time.

Answer: TRUE

Diff: 2 Page Ref: 19.6N

FILL-IN-THE-BLANK. Write the word or phrase that best completes each statement or answers the question.

1) Dense clouds of _____ and gas are probably the birthplaces of stars.

Answer: dust

Diff: 1 Page Ref: 19.1R

2) The birthplaces of stars correspond to the _____ clouds in the interstellar medium.

Answer: densest (and coldest)

Diff: 2 Page Ref: 19.1R

3) Messier 42, the Great Nebula in Orion, is, for observers in the United States, the most obvious region of current:

Answer: star formation (or star birth).

Diff: 1 Page Ref: 19.1

4) To deduce the interior conditions of the dense regions in which stars form, it is necessary for astronomers to observe in the _____ part of the spectrum.

Answer: infrared

Diff: 2 Page Ref: 19.1

5) During the Hayashi track a star drops drastically in both:

Answer: size and luminosity.

Diff: 2 Page Ref: 19.2

6) A star's core temperature must reach _____ K before hydrogen fusion can begin.

Answer: ten million

Diff: 1 Page Ref: 19.2

7) After stage 3 in star formation, the protostar develops a surface, better known as a:

Answer: photosphere.

Diff: 1 Page Ref: 19.2

8) During the Kelvin-Helmholtz contraction phase, a protostar has a much _____ brightness as compared to the Sun.

Answer: higher

Diff: 2 Page Ref: 19.2

9) If a brown dwarf is to be hot enough to be seen in visible light, it must be during the _____ phase.

Answer: Kelvin-Helmholtz contraction

Diff: 3 Page Ref: 19.2

10) An evolutionary track plots the changes in a star's life on the:

Answer: H-R or Hertzsprung-Russell Diagram.

Diff: 2 Page Ref: 19.2

11) It probably took our Sun about _____ million years to stabilize on the main sequence.

Answer: 50

Diff: 2 Page Ref: 19.2

12) More massive stars are able to form in a _____ time than less massive stars.

Answer: shorter

Diff: 1 Page Ref: 19.3

13) If a protostar's mass is too low, instead of forming a star, it will become a _____ dwarf.

Answer: brown

Diff: 1 Page Ref: 19.3

14) Brown dwarfs range from _____% of the Sun's mass down to about 12 Jupiter masses.

Answer: 8

Diff: 2 Page Ref: 19.3N

15) If an object was found to be ten Jupiter masses, it is technically a:

Answer: planet (even if it is not orbiting a star).

Diff: 2 Page Ref: 19.3N

16) Below a limit of .08 solar masses, protostars make _____ dwarfs.

Answer: brown

Diff: 1 Page Ref: 19.3R

17) While some might regard Jupiter as a "brown dwarf," in fact objects up to _____ times its mass will still not ignite hydrogen or even deuterium fusion and reach the main sequence via nuclear fusion.

Answer: 12

Diff: 3 Page Ref: 19.3

18) Objects which have contracted, but are of too little mass to establish thermonuclear reactions in their cores, are _____, which slowly continue to cool.

Answer: brown dwarfs

Diff: 1 Page Ref: 19.3

19) In the HR Diagram the positions of stars of different masses that have just stopped contracting and have begun to burn hydrogen at a steady rate in their cores are known as the:

Answer: zero age main sequence.

Diff: 2 Page Ref: 19.3

20) In general, the greater the mass of the protostar, the _____ it contracts to the main sequence.

Answer: faster

Diff: 1 Page Ref: 19.3N

21) The strongest stellar winds from a protostar blow from its:

Answer: poles.

Diff: 1 Page Ref: 19.4

22) The formation of stars from interstellar clouds is an inefficient process, as shown by the observation of strong protostellar _____, which return material to the interstellar medium.

Answer: winds or bipolar jets

Diff: 2 Page Ref: 19.4

23) In the dusty disk of the protostar, much of the material eventually accretes into:

Answer: planets.

Diff: 1 Page Ref: 19.4

24) _____ variable stars are pre-Main Sequence stars undergoing gravitational contraction and exhibiting erratic changes in their luminosities.

Answer: T Tauri

Diff: 2 Page Ref: 19.4

25) Material shed outward in the bipolar flows around protostars are called _____ objects.

Answer: Herbig-Haro

Diff: 2 Page Ref: 19.4

26) A protostar develops a bipolar flow of gas when it is still surrounded by an equatorial disk of:

Answer: dust.

Diff: 1 Page Ref: 19.4

27) Star formation may be triggered by _____ which aid gravity through compression of interstellar clouds to greater densities.

Answer: pressure or shock waves (from supernovae)

Diff: 1 Page Ref: 19.5

28) The most prolific regions of star formation result from _____ of galaxies.

Answer: collisions

Diff: 2 Page Ref: 19.5N

29) The _____ star clusters are the oldest and richest, over ten billion years old.

Answer: globular

Diff: 2 Page Ref: 19.6N

30) The youngest open clusters lie in the galactic plane and appear _____ in color.

Answer: blue

Diff: 1 Page Ref: 19.6N

TRUE/FALSE. Write 'T' if the statement is true and 'F' if the statement is false.

1) Every red dwarf star that ever joined the main sequence is still there today.

Answer: TRUE

Diff: 2 Page Ref: 20.1

2) Evolution of a star off the main sequence is caused by the loss of mass from hydrogen fusion by the star while a main sequence star.

Answer: FALSE

Diff: 1 Page Ref: 20.1

3) When helium fusion begins in a one solar mass main star, it begins gradually, with this rate slowly increasing over time.

Answer: FALSE

Diff: 2 Page Ref: 20.2

4) The Sun will get brighter in the next 4 to 5 billion years.

Answer: TRUE

Diff: 2 Page Ref: 20.2

5) While more massive than most of its neighbors, the Sun is still technically a low mass star.

Answer: TRUE

Diff: 2 Page Ref: 20.2

6) When a star becomes a red giant, its core expands to a roughly proportional larger size too.

Answer: FALSE

Diff: 1 Page Ref: 20.2

7) As a star begins to evolve away from the main sequence, it gets larger.

Answer: TRUE

Diff: 2 Page Ref: 20.2R

8) During and after the helium flash, there is a decrease in the star's luminosity and it becomes stable for a while.

Answer: TRUE

Diff: 2 Page Ref: 20.2R

9) Eventually, all low mass stars will become white, then black, dwarfs.

Answer: TRUE

Diff: 1 Page Ref: 20.3

10) The matter in white dwarfs is about a million times denser than matter around you, since you have packed the mass of the Sun into the volume of our Earth.

Answer: TRUE

Diff: 2 Page Ref: 20.3R

11) The shell ejection in making a planetary is spherical and symmetrical in all cases.

Answer: FALSE

Diff: 2 Page Ref: 20.2

12) Hubble images prove many planetary nebulae possess bipolar symmetry, and may be products of close binary systems.

Answer: TRUE

Diff: 2 Page Ref: 20.3N

13) All planetary nebulae are slowly-expanding spherical disks ejected by red giants, while their exposed cores appear as white dwarfs.

Answer: FALSE

Diff: 2 Page Ref: 20.3R

14) The Sun will become a red giant, then a white dwarf, and finally a brown dwarf.

Answer: FALSE

Diff: 2 Page Ref: 20.3

15) While none yet exist, in the very distant future, black dwarfs will comprise the majority of the "normal matter" of the universe.

Answer: TRUE

Diff: 3 Page Ref: 20.3R

- 16) Today the majority of the "missing mass" of the universe is already in the form of black dwarfs.
Answer: FALSE
Diff: 2 Page Ref: 20.3R
- 17) There is no helium flash for a high mass star; for them, it is just one more step toward the heaviest element formation.
Answer: TRUE
Diff: 2 Page Ref: 20.4R
- 18) High mass stars are defined as those with masses above about four solar masses.
Answer: FALSE
Diff: 2 Page Ref: 20.4
- 19) Low mass stars should produce white dwarfs, while high mass stars will produce more compact end products.
Answer: TRUE
Diff: 2 Page Ref: 20.4N
- 20) A massive star does not change its luminosity significantly while evolving beyond the main sequence, even though its color and spectral type may evolve.
Answer: TRUE
Diff: 2 Page Ref: 20.4
- 21) Sirius B started out more massive than the bright companion that is now our brightest star in the sky, the present white dwarf probably was initially about four solar masses.
Answer: TRUE
Diff: 2 Page Ref: 20.4N
- 22) The Sirius system could not be the way it is now without mass transfer in the past.
Answer: TRUE
Diff: 2 Page Ref: 20.4N
- 23) The rarest of white dwarfs are the ones that go all the way to making neon.
Answer: TRUE
Diff: 3 Page Ref: 20.4N
- 24) For our Sun, the production of carbon will be the end of its nucleosynthesis.
Answer: TRUE
Diff: 3 Page Ref: 20.4N
- 25) A star cluster of age 100 million years contains no type O stars.
Answer: TRUE
Diff: 2 Page Ref: 20.5
- 26) While still blue in color, the seven famous sisters of the Pleiades are in fact plotted a little above the main sequence and have already started to leave the main sequence, explaining their high luminosity.
Answer: TRUE
Diff: 2 Page Ref: 20.5N
- 27) Globular star clusters are dominated by class O and B stars on the main sequence.
Answer: FALSE
Diff: 2 Page Ref: 20.5R
- 28) The age of a star cluster can be determined by the luminosity of the main sequence turnoff into the giant stage.

Answer: TRUE

Diff: 2 Page Ref: 20.5R

29) A ten billion year old globular cluster has every star evolved into a giant, with no main sequence stars left.

Answer: FALSE

Diff: 2 Page Ref: 20.5R

30) The blue stragglers represent the horizontal branch for a globular star cluster.

Answer: FALSE

Diff: 3 Page Ref: 20.5

31) Blue stragglers are excellent examples of binary mass transfer in action.

Answer: TRUE

Diff: 2 Page Ref: 20.6

32) Although mass transfer can occur in binary stars, it is never sufficient to affect the evolution of either star.

Answer: FALSE

Diff: 1 Page Ref: 20.6

33) Mass transfer will occur when either companion swells to reach the Roche lobe of its twin.

Answer: TRUE

Diff: 2 Page Ref: 20.6N

34) For visual binaries, mass transfer is not an issue.

Answer: TRUE

Diff: 3 Page Ref: 20.6N

35) Mass transfer will almost always occur for spectroscopic and eclipsing binaries.

Answer: TRUE

Diff: 3 Page Ref: 20.6N