1. The most common element in the universe is
   a. water.
   b. silicon.
   c. carbon.
   d. hydrogen.
   e. helium.

2. The nucleus of a comet consists of
   a. atoms that have gained or lost electrons.
   b. frozen gas, ice, and dust.
   c. mostly rock and iron.
   d. a cloud of vaporizing gas and dust.
   e. freely falling individual dust particles.

3. In the Earth's atmosphere, the percentage that is Oxygen is roughly
   a. 1%.
   b. 80%.
   c. 20%.
   d. 0.04%.
   e. 50%.

4. It has been theorized that planets do not easily form in binary star systems. If they do form, there are three possible arrangements: (1) Planets with orbits similar in radius to the distance between the two stars. (2) Planets with orbits much smaller in radius than the distance between the two stars. (3) Planets with orbits much larger in radius than the distance between the two stars. Observations so far (2009) indicate that
   a. possibilities (1) and (2) actually happen.
   b. possibilities (2) and (3) actually happen.
   c. possibilities (1) and (3) actually happen.
   d. all of these possibilities actually happen.
   e. none of these possibilities actually happens.

5. In the original Solar Nebula, objects that condensed far from the protoSun tended to include large amounts of frozen gas and water ice because, in that part of the nebula
   a. there was little rock and iron.
   b. there was a great deal of gas and water.
   c. it was cold enough for gases and water to condense.
   d. it was too hot for rock and iron to condense.

6. The asteroid 2007 VK184 has one chance in 2940 of hitting the Earth between the years 2048 and 2057. The asteroid is 130 meters in diameter or about half the size of Apophis. Assuming that an impact could cause the death of 1,000,000 people the average death rate for this type of event is closest to
   a. 100 people per event.
   b. 250 people per event.
   c. 350 people per event.
   d. 10 people per event.
7 Comets that originate in the Inner Oort Cloud would be expected to have orbits that are
   a. at all angles to the plane of the solar system.
   b. mostly close to the plane of the solar system.
   c. mostly perpendicular to the plane of the solar system.

8 Liquid water tends to permanently remove carbon dioxide from the atmosphere of a planet by
   a. splitting the carbon from the oxygen.
   b. forming an acid which reacts with calcium in rocks.
   c. displacing it upward until it escapes from the planet’s gravity.
   d. dissolving it.

9 The early Earth probably had carbon
   a. in the form of amino acids and other complex hydrocarbons.
   b. only in the form of carbon dioxide.
   c. in the form of coal and methane.

10 The Greenhouse Effect is important because it suggests an effect on
    a. the Earth’s rotation.
    b. shielding UV light from the Sun.
    c. the Earth’s climate.
    d. the availability of greenhouses.
    e. near-Earth asteroids.

11 A spectrum is defined to be the set of
    a. energy levels missing from a light source.
    b. photons present in a light source.
    c. frequencies or colors missing from a light source.
    d. frequencies or colors present in a light source.
    e. energy levels in a light source.

12 Compared to the frequency of photons absorbed during a transition from a -5ev state to a -4ev state, transitions
   from the -5ev state to a -2ev state would correspond to absorbing photons whose frequency is
    a. 4 times as high.
    b. 5 times as high.
    c. 2 times as high.
    d. the same.
    e. 3 times as high.

13 The layer of the Earth’s interior that consists of dense, semiliquid material is the
    a. mantle.
    b. mesosphere.
    c. outer core.
    d. inner core.
    e. crust.
14 A pair of sugar phosphate chains connected by pairs of nitrogenous bases describes a molecule of
   a. glycoaldehyde.
   b. DNA.
   c. RNA.
   d. glucose.
   e. chlorophyll.

15 The molecules of both liquid water and ice are held together by
   a. transferring electrons between water molecules to make electrically charged ions.
   b. weak electrical fluctuations in one water molecule and the opposite electrical fluctuations that it induces in another.
   c. sharing electrons between water molecules.
   d. the attraction between the hydrogen atoms on one water molecule and the oppositely charged oxygen atom on another.

16 Silicon atoms can bond to other silicon atoms to form polysilylene molecules in much the same way that carbon atoms can bond to other carbon atoms to form sugars and other hydrocarbon molecules. What is the key difficulty with basing life on silicon and polysilylenes instead of on carbon compounds such as glucose?
   a. polysilylenes cannot contain hydrogen.
   b. polysilylenes tend to explode in the presence of oxygen.
   c. Silicon is less abundant than carbon.
   d. Glucose stores more energy than polysilylenes.
   e. polysilylenes cannot release energy by oxidation.

17 The reason the temperature rises as you go higher in the Ionosphere is that the Sun’s
   a. high energy particles heat the upper part of the Ionosphere.
   b. ultraviolet light heats the Ozone Layer.
   c. visible light heats the land.

18 Of the following methods for eliminating an asteroid threat, which one would be affected least by the unknown composition and condition of the asteroid?
   a. Deflect or shatter the asteroid by crashing a whole fleet of missiles into it.
   b. Deflect or shatter the asteroid with a series of nuclear explosions.
   c. Land on an iron asteroid, attach a rocket to it, and use its gravitational attraction to pull the target asteroid off course.
   d. Land on the asteroid and attach a rocket to it, and use the rocket’s thrust to drive the asteroid off course.
   e. Attach a line to the asteroid and pull it off course by towing it with a massive spacecraft.

19 Jupiter failed to become a star because
   a. It was made from the wrong material.
   b. When Jupiter ignited, the proto-Sun blew it out.
   c. The proto-Sun’s final collapse blew all the gas away.
   d. The proto-Sun’s gravity prevented it from growing.
   e. It was too far from the proto-Sun.
20 Which layer of the Earth has a thickness of only about ten miles?
   a. The liquid part of the iron core.
   b. The mantle.
   c. The crust.

21 A very large number of new asteroids have been discovered since 1990 primarily because
   a. space probes have been used to look for them.
   b. more astronomers have been looking for them.
   c. telescopes started using digital imaging instead of film.
   d. orbiting infrared observatories have been used to look for them.

22 The ion tail of a comet
   a. consists of straight streamers.
   b. is curved and fuzzy-looking.
   c. is a ball around the nucleus.
   d. shoots out in random directions.

23 The Oort Cloud
   a. is no longer accepted as the starting point of long-period comets.
   b. is the hypothetical (but mostly unobserved) starting point of short-period comets.
   c. is the hypothetical (but mostly unobserved) starting point of long-period comets.
   d. has been confirmed now that hundreds of objects in the cloud have been observed.

24 When water freezes, the resulting ice occupies
   a. more volume than the liquid water did.
   b. the same volume that the liquid water did.
   c. less volume than the liquid water did.

25 Most plants here on Earth are green because the process of converting carbon dioxide and water into organic
   matter uses only
   a. green light.
   b. red, blue, and violet light.
   c. red, blue, green, and violet light.
   d. blue and violet light.
   e. red light.

26 Venus retains a dense carbon dioxide atmosphere because
   a. there is no plate tectonic activity in its crust.
   b. there is no liquid water there.
   c. there is no life there.

27 Which of the following systems do most living things on Earth now use to reproduce themselves?
   a. Each enzyme acts as a pattern to make copies of itself.
   b. Each DNA molecules splits in half and each half acts as a pattern to complete its other half.
   c. Each RNA molecules acts as a pattern to make copies of itself.
28 Which of the following types of radiation has the highest frequency on this list?
   a. Radio waves.
   b. heat radiation.
   c. green light.
   d. infrared light.
   e. red light.

29 An asteroid whose impact generates a planet-wide catastrophe, changing the climate everywhere, probably has a diameter of about
   a. 1 meter.
   b. 1000 to 10,000 meters.
   c. 100,000 meters or larger.
   d. 50 meters.

30 Which of the following Trans Neptunian Objects is thought to be a visitor from the Inner Oort Cloud?
   a. Varuna.
   b. Sedna.
   c. Pluto.
   d. Quaoar.
   e. Eris.

31 It has been argued that hydrogen-powered automobiles can solve our energy problems because we can get all of the hydrogen that we need from sea water. Which of the following comments about the energy needed to separate the hydrogen and oxygen in water is correct?
   a. It is less than the energy released when the hydrogen is burned, so we get a net gain of energy.
   b. It is the greater than the energy released when the hydrogen is burned, so we get a net loss of energy.
   c. It is the same as the energy released when the hydrogen is burned, so we get no net gain of energy.

32 Because the radiant of the Lyrid meteor shower is in the constellation Lyra, you can conclude that
   a. the Earth is moving toward Lyra when it passes through the remains of the comet.
   b. the comet that gave rise to the Lyrids was moving in the direction of Lyra when it broke up.
   c. the comet that gave rise to the Lyrids originally came from Lyra.
   d. the Sun is moving in the direction of the constellation Lyra.

33 When detailed tracking of asteroid 2008 TC₃ showed that it would hit the Earth, the asteroid officially became a
   a. meteor.
   b. meteoroid.
   c. comet.
   d. meteorite.

34 Gerard Kuiper predicted that the region we now call the "Kuiper Belt" should be empty.
   a. He was incorrect because he assumed a mass for Pluto that is now known to be too large.
   b. He was incorrect because his calculations were wrong.
   c. He was correct, which is why the region was named after him.
   d. He was incorrect because he assumed a mass for Pluto that is now known to be too small.
35 Underneath a place where the sea floor is spreading, one expects there to be
   a. a horizontal current in the Earth’s mantle.
   b. a rising convection current in the Earth’s mantle.
   c. a descending convection current in the Earth’s mantle.
   d. a magnetic domain in the Earth’s core.
   e. a bubble in the Earth’s mantle.

36 You are standing at the edge of a great desert at noon time. In front of you is a sea of hot sand. Behind you is the coolness of a green and growing forest. Which way is the wind most likely blowing?
   a. toward the desert.
   b. along the line between desert and forest.
   c. toward the forest.

37 The objects of the Kuiper belt are mostly orbiting
   a. beyond all of the Jovian planets.
   b. between the orbits of Earth and Mars.
   c. among the Jovian planets.
   d. within the asteroid belt.

38 On Earth, a stable carbon cycle could not exist without
   a. plate tectonics recycling the sea floor into the Earth’s interior.
   b. plants turning carbon dioxide into organic material.
   c. the burning of fossil fuels.
   d. the decay of dead plant matter.
   e. animals breathing out carbon dioxide.

39 If the frequency of electromagnetic radiation goes from $2 \times 10^{14}$ Hz to $6 \times 10^{14}$ Hz, the energy of each individual photon in the radiation
   a. is divided by 3.
   b. is divided by 2.
   c. does not change.
   d. is multiplied by 3.
   e. is multiplied by 2.

40 Suppose that an asteroid, about 1 kilometer in diameter, shows a 1 in 100 probability of an Earth impact fifty years in the future. Assume that an impact will trigger climate changes that would kill one billion ($1,000,000,000$) people. Also assume that each of these deaths represents $100,000$ in lost production. Using the cold economic logic that we discussed in class, how much money should be budgeted to deflect the asteroid?
   a. one billion dollars ($1,000,000,000$)
   b. one hundred billion dollars ($100,000,000,000$).
   c. one trillion dollars ($1,000,000,000,000$).
   d. one hundred trillion dollars ($100,000,000,000,000$).
41 When the fireball of its entry into the atmosphere was spotted from a KLM airliner, asteroid 2008 TC₃ had officially become a
   a. meteoroid.
   b. comet.
   c. meteorite.
   d. meteor.

42 The portion of the Earth that is solid iron and nickel is the
   a. mesosphere.
   b. mantle.
   c. crust.
   d. outer core.
   e. inner core.

43 The Tunguska Event in 1908 is thought to have been caused by
   a. an asteroid about 30 meters in diameter.
   b. a secret Imperial Russian nuclear test.
   c. an asteroid about 300 meters in diameter.
   d. the crash of an alien spacecraft.
   e. a microscopic black hole.

44 Short-period comets are thought to be
   a. Asteroid belt objects deflected by Jupiter.
   b. long period comets deflected by Neptune.
   c. long period comets deflected by Jupiter.
   d. Kuiper belt objects deflected by Jupiter.
   e. Kuiper belt objects deflected by Neptune.

45 As seen from far above the Earth’s North Pole, the Earth orbits the Sun counter-clockwise and
   a. the Jovian planets orbit the Sun clockwise.
   b. Venus orbits the Sun clockwise.
   c. Mercury orbits the Sun clockwise.
   d. No planet orbits the Sun clockwise.

46 If we should find micro-organisms on Mars that reproduce using a DNA/RNA scheme and set of amino acids that are identical to those used in all Earth life-forms, that would support the
   a. Abiogenesis Chimera Model.
   b. The Spontaneous Generation Model.
   c. Panspermia Model.
   d. Single Original Abiogenesis Model.

47 Which of the following types of radiation has the second lowest frequency on this list?
   a. Radio waves.
   b. infrared light.
   c. red light.
   d. green light.
   e. heat radiation.
48 The Oort cloud of our Sun reaches
   a. at least a quarter of the way to the nearest star.
   b. most of the way to the nearest star.
   c. a negligible part of the distance from our Sun to the nearest star.
   d. beyond several of the nearest stars to our Sun.

49 The epicenters of earthquakes are located
   a. mostly near the Earth’s equator.
   b. mostly along the edges of moving plates.
   c. mostly along continental boundaries.
   d. mostly in the centers of oceans.
   e. at random places on the Earth’s surface.

50 The number of protostars that can be seen right now is
   a. large because they are much brighter than ordinary stars.
   b. large because they last a long time.
   c. small because they are not very bright.
   d. small because they do not last very long before they turn into stars.
Answer Key: Spring 2017 HX3M

1 Choice d. (hydrogen.)
2 Choice b. (frozen gas, ice, and dust.)
3 Choice c. (20%.)
4 Choice b. (possibilities (2) and (3) actually happen.)
5 Choice c. (it was cold enough for gases and water to condense.)
6 Choice c. (350 people per event.)
7 Choice b. (mostly close to the plane of the solar system.)
8 Choice b. (forming an acid which reacts with calcium in rocks.)
9 Choice a. (in the form of amino acids and other complex hydrocarbons.)
10 Choice c. (the Earth’s climate.)
11 Choice d. (frequencies or colors present in a light source.)
12 Choice e. (3 times as high.)
13 Choice a. (mantle.)
14 Choice b. (DNA.)
15 Choice d. (the attraction between the hydrogen atoms on one water molecule and the oppositely charged oxygen atom on another.)
16 Choice b. (polysilylenes tend to explode in the presence of oxygen.)
17 Choice a. (high energy particles heat the upper part of the Ionosphere.)
18 Choice c. (Land on an iron asteroid, attach a rocket to it, and use its gravitational attraction to pull the target asteroid off course.)
19 Choice c. (The proto-Sun’s final collapse blew all the gas away.)
20 Choice c. (The crust.)
21 Choice c. (telescopes started using digital imaging instead of film.)
22 Choice a. (consists of straight streamers.)
23 Choice c. (is the hypothetical (but mostly unobserved) starting point of long-period comets.)
24 Choice a. (more volume than the liquid water did.)
25 Choice b. (red, blue, and violet light.)
26 Choice b. (there is no liquid water there.)
27 Choice b. (Each DNA molecules splits in half and each half acts as a pattern to complete its other half.)
28 Choice c. (green light.)
29 Choice b. (1000 to 10,000 meters.)
30 Choice b. (Sedna.)
31 Choice c. (energy.) (It is the same as the energy released when the hydrogen is burned, so we get no net gain of energy.)
32 Choice a. (the Earth is moving toward Lyra when it passes through the remains of the comet.)
33 Choice b. (meteoroid.)
34 Choice a. (He was incorrect because he assumed a mass for Pluto that is now known to be too large.)
35) Choice b. (a rising convection current in the Earth’s mantle.)
36) Choice a. (toward the desert.)
37) Choice a. (beyond all of the Jovian planets.)
38) Choice a. (plate tectonics recycling the sea floor into the Earth’s interior.)
39) Choice d. (is multiplied by 3.)
40) Choice c. (one trillion dollars ($1,000,000,000,000).)
41) Choice d. (meteor.)
42) Choice e. (inner core.)
43) Choice a. (an asteroid about 30 meters in diameter.)
44) Choice e. (Kuiper belt objects deflected by Neptune.)
45) Choice d. (No planet orbits the Sun clockwise.)
46) Choice c. (Panspermia Model.)
47) Choice e. (heat radiation.)
48) Choice a. (at least a quarter of the way to the nearest star.)
49) Choice b. (mostly along the edges of moving plates.)
50) Choice a. (large because they are much brighter than ordinary stars.)
Where to find these questions in the notes

1. Module 018.201 Requirements for Life The Chemical Basis of Life
2. Module 013.101-g01 Comets and the Outer Solar System Comets in Detail
3. Module 015.104-g01 Earth’s Atmosphere and Interior A Thin Layer of Air
4. *Module 014.403-g01 Formation of the Solar System Jupiter Loses the Race (35%)
5. Module 014.302 Formation of the Solar System Condensation of the Planets
6. Module 017.405 Earth Impacts Hunting Killer Asteroids
7. *Module 013.404 Comets and the Outer Solar System The Transition from Kuiper Belt to Oort Cloud (35%)
8. **Module 016.304 Earth’s Living Surface The Carbon Cycle (33%)
9. Module 018.312 Requirements for Life The Requirements for a Carbon Cycle (42%)
10. Module 015.403 Earth’s Atmosphere and Interior Greenhouse Effect
11. Module 018.116 Requirements for Life Light
12. Module 018.111 Requirements for Life Light
13. Module 015.504 Earth’s Atmosphere and Interior The Earth’s Interior
14. Module 018.502 Requirements for Life Reproduction
15. Module 018.305 Requirements for Life The Requirements for a Carbon Cycle
16. Module 018.204 Requirements for Life The Chemical Basis of Life
17. Module 015.307-g01 Earth’s Atmosphere and Interior Temperature Layers
18. Module 017.501-g01 Earth Impacts Asteroid Defense
19. Module 014.401 Formation of the Solar System Jupiter Loses the Race
20. Module 015.502 Earth’s Atmosphere and Interior The Earth’s Interior
21. Module 017.105 Earth Impacts Near Earth Objects
22. *Module 013.103 Comets and the Outer Solar System Comets in Detail (37%)
23. Module 013.301-g01 Comets and the Outer Solar System The Origin of Comets
24. Module 018.307 Requirements for Life The Requirements for a Carbon Cycle
25. Module 018.404-g01 Requirements for Life The Energy Sources of Life
26. Module 016.501 Earth’s Living Surface Comparing Earth to Other Planets
27. EModule 018.503 Requirements for Life Reproduction (F20113:86%,86%)
28. ***Module 018.101-g01 Requirements for Life Light (28%)
29. Module 017.302 Earth Impacts Large Object Impacts
30. Module 013.401-g01 Comets and the Outer Solar System The Transition from Kuiper Belt to Oort Cloud
31. Module 018.401 Requirements for Life The Energy Sources of Life
32. Module 013.205-g01 Comets and the Outer Solar System Meteor Showers
33. Module 013.202-g01 Comets and the Outer Solar System Meteor Showers
34. Module 014.505-g01 Formation of the Solar System The Fates of Dirty Snowballs
35. Module 016.105 Earth’s Living Surface An Active Crust
36. Module 015.201-g01 Earth’s Atmosphere and Interior Convection
37 Module 013.306 Comets and the Outer Solar System The Origin of Comets
38 Module 016.402 Earth’s Living Surface Closing the Carbon Cycle
39 Module 018.107 Requirements for Life Light
40 **Module 017.406-g01 Earth Impacts Hunting Killer Asteroids (32%)**
41 Module 013.201-g01 Comets and the Outer Solar System Meteor Showers
42 Module 015.506-g01 Earth’s Atmosphere and Interior The Earth’s Interior
43 Module 017.201-g01 Earth Impacts Small Object Impacts
44 Module 013.308 Comets and the Outer Solar System The Origin of Comets (43%)
45 EModule 014.103 Formation of the Solar System The Solar Nebula (F20113:74%)
46 *Module 018.510 Requirements for Life Reproduction (38%)
47 Module 018.101-g02 Requirements for Life Light
48 Module 013.501 Comets and the Outer Solar System Beyond the Oort Cloud
49 Module 016.202 Earth’s Living Surface An Active Crust
50 Module 014.204 Formation of the Solar System The Protostar Stage