**SPU-14 How to Build Habitable Planet**

**Final Exam Fall 2012**

**NAME\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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**True-False: Evaluate the statements given below.. IF they are false, change the sentence to make it true without using a simple negative. (3 points each) (57 points total)**

1. \_\_\_\_\_\_\_ Earth’s magnetic field is derived from the inner core, which is more likely to convect than the outer core because the inner core is at higher temperature.
2. \_\_\_\_\_\_\_\_GPS has provided definitive proof of plate tectonics, because it shows that plate velocities that can be measured today are similar to those estimated from magnetic anomalies.
3. \_\_\_\_\_\_\_\_\_Hydrothermal circulation at spreading centers is a mechanism by which an initially dry ocean crust absorbs water into hydrous minerals.
4. \_\_\_\_\_\_\_\_\_Formation of organic molecules is an essential precursor to the origin of life, and has been demonstrated to be able to take place in diverse environments, including outer space and Earth’s atmosphere.
5. \_\_\_\_\_\_\_\_Evolution can be studied more easily in animals than in bacteria, because in bacteria evolutionary changes are so small as to be invisible.
6. \_\_\_\_\_\_\_\_The oxidized and reduced reservoirs of the planetary fuel cell have all been present since the beginning of Earth history.
7. \_\_\_\_\_\_\_\_Uranium minerals provide evidence for the history of oxygen in Earth’s atmosphere.
8. \_\_\_\_\_\_\_\_Carbon isotopes can be used to explore the history of oxygen production over geological time.
9. \_\_\_\_\_\_\_\_Metals such as copper and zinc are in abundance today, but our increasing use of these metals is likely to lead to great shortages in the future as ore deposits become exhausted.
10. \_\_\_\_\_\_\_\_Saudi Arabia has been able to maintain productive agriculture by making use of abundant groundwater resources that were created during the last ice age.
11. \_\_\_\_\_\_\_\_The average citizen in the United States uses about twice as much energy as the average citizen in China.
12. \_\_\_\_\_\_\_\_The CO2 content of the atmosphere today is higher than it has been anytime in the last 600,000 years.
13. \_\_\_\_\_\_\_\_While thousands of planets are now being discovered around other stars, none of them are exactly like Earth, suggesting Earth-like planets are probably very rare in the Milky Way Galaxy.
14. \_\_\_\_\_\_\_\_Most of the terms in the Drake Equation are uncertain by at least a factor of two.
15. \_\_\_\_\_\_\_\_The most abundant element in the universe is helium.
16. \_\_\_\_\_\_\_\_There are a few thousand minerals on Earth, and the most common minerals in Earth’s crust are silicates. In contrast, there are only a few hundred organic molecules.
17. \_\_\_\_\_\_\_\_Alpha decay, beta decay, and electron capture always involve a change in the identity of the element that is decaying.
18. \_\_\_\_\_\_\_\_\_The mass of all the planets in the solar system is comparable to the mass of the Sun.
19. \_\_\_\_\_\_\_\_\_Radioactivity serves no useful function on Earth, and is simply a hazard that needs to be managed.

**Multiple choice: Circle the single best answer for each question (2 points each) (64 points total)**

1. Continents in plate tectonic theory are:

A Actively created and destroyed

B Boundaries between plates

C The force driving plate motion

D Passive features riding on plates

E All of the above

2. Explosive volcanoes occur at subduction zones because:

A Subduction zones are sites of active upwelling

B The mantle is hotter there

C The magmas have a higher volatile content

D Continental crust has a high content of radioactive elements

E The volcanoes have to explode to make it through the thick continental crust

3. Nuclei heavier than 56Fe are rare because:

A Creating them requires extremely high-energy environments

B Nuclei heavier than 56Fe quickly decay

C The sun only burns hydrogen to make helium

D Supernovas efficiently destroy heavy nuclei

E They have heavier masses than light isotopes

4. Iron meteorites have:

A Large olivine crystals

B Chondrules

C CAIs (calcium-aluminum inclusions)

D High contents of siderophile elements

E All of the above

5. The short-lived Hf-W radioactive system allows us to date core formation because:

A 182Hf is only formed in supernovas

B 182Hf is formed continuously in the atmosphere

C Hf is refractory and W is volatile

D Hf is lithophile and W is siderophile

E Hf is siderophile and W is lithophile

6. Carbon is \_\_\_\_\_ in CO2, and \_\_\_\_\_ in organic molecules.

A reduced, oxidized

B oxidized, reduced

C insoluble, soluble

D soluble, insoluble

E +2, -2

7. The eastern edge of South America is a:

A Convergent margin

B Divergent margin

C Passive margin

D Transform fault

E None of the above

8. Buried organic carbon is a proxy for global oxidation because:

A Buried organic carbon oxidizes in the mantle

B Carbon can exist in multiple oxidation states

C Production of organic carbon also produces oxygen

D Life prefers isotopically heavy carbon

E Life prefers isotopically light carbon

9. The 20,000–100,000 year timescale of climate change is due to:

A Earth’s orbital cycles

B The tectonic thermostat

C Burning of fossil fuels

D Variability in solar output

E Changes in Earth’s magnetic field

10. Evidence for a meteorite impact at the time of the K-T boundary (65 million years ago) does NOT include:

A Discovery of the meteorite itself in the Yucatan Peninsula

B High iridium content in strata

C Impact ejecta found in North America

D A tsunami recorded in sediments in Florida

E Discovery of the impact crater

11. Banded iron formations formed during periods of global oxidation because:

A Iron forms magnetic anomalies (“stripes”) at mid-ocean ridges

B Magnetic reversals at that time created banded sedimentary layers of iron and silica

C Iron is an essential nutrient for life

D Local regions where oxidation was occurring led to Fe precipitation

E Oxidized iron is soluble in seawater, leading to high concentrations

12. The Miller-Urey experiment demonstrated that:

A The origin of life was not spontaneous generation

B Earth’s early atmosphere was very different than today’s

C Organic molecules could be made abiotically

D Life began from lightning strikes on pre-biotic material

E Early Earth was able to make polymers essential for life including DNA

13. The age of the Earth is:

A 5773 years

B 543 million years

C 4.5 billion years

D 6.2 billion years

E 14 billion years

14. The solar system is roughly \_\_\_\_\_ the age of the universe.

A 1/10

B 1/4

C 1/3

D 1/2

E 3/4

15. The fundamental building blocks of minerals in the Earth are:

A C-C and C-H bonds

B Na+ cations and Cl- anions

C The alpha-particle nuclides 4He, 12C, 16O, and 20Ne

D C, Fe, and Mg

E Silica tetrahedra

16. Professor Langmuir was an undergraduate at:

A Harvard

B Yale

C UC Berkeley

D Brown

E UCLA

17. The inner planets are \_\_\_\_\_ the outer planets.

A More dense than

B Less dense than

C About the same density as

D Some are denser and some are lighter

E None of the above

18. With the exception of a few volatile elements, \_\_\_\_\_ has/have the same composition as the sun.

A Carbonaceous chondrites

B Interstellar dust

C Pallasites

D Iron meteorites

E Earth’s mantle

19. The Earth is mostly made up of:

A Rock

B Rock and metal

C Rock and ice

D Granite and basalt

E Granite, basalt, and ice

20. The 2.7 K blackbody temperature of the universe is a result of:

A Heavy element production in supernovas

B Extremely red-shifted galaxies

C The fusing of hydrogen into helium

D Gradual heating of the Universe by star formation

E The Big Bang

21. The number of confirmed planets outside our solar system is:

A None

B A few dozen

C A few hundred

D Tens of thousands

E More than one hundred thousand

22. The best current theory for the formation of the Moon involves:

A The Moon is “thrown off” a rapidly spinning Earth

B The Moon forms elsewhere and is captured by Earth’s gravity

C The Moon forms from remnants of a giant impact between Earth and Mars

D The Moon condensed from the solar nebular around the Earth, like the moons of the outer planets

E None of the above

23. The Earth is a “planetary fuel cell” in that:

A Hydrogen and oxygen combine in the upper atmosphere

B It has evolved reservoirs of reduced and oxidized material

C Geothermal heat is thought to power earliest life

D Heat transport by convection enables plate tectonics

E Iron meteorites and carbonaceous chondites provided reduced and oxidized materials

24. Oceanic crust is \_\_\_\_\_ continental crust.

A Thicker than

B More dense than

C More felsic than

D Underneath

E Older than

25. 147Sm decaying to 143Nd is an example of:

A Alpha decay

B Beta decay

C Electron capture

D Spontaneous fission

E None of the above

26. Any gas molecule with three or more atoms is:

A More oxidized than molecules with two atoms

B Insoluble in water

C Emitted by volcanos

D A greenhouse gas

E More volatile than the atoms that make it up

27. The Earth’s crust is made from:

A Metal-silicate separation by immiscibility

B Crystallization of an early magma ocean

C Multiple melting or igneous events beginning with partial melts of the mantle

D The remnants of meteorite bombardment

E All of the above

28. Large igneous provinces (LIPs) are associated with:

A Global oxidation

B Meteorite impacts

C Mass extinctions

D Banded iron formations (BIFs)

E None of the above

29. Aerobic respiration:

A Primarily happens in prokaryotes

B Was the first metabolism to evolve

C Makes use of oxygen

D Produces fewer ATP than anaerobic respiration

E Is the primary way that oxygen was created in Earth history

30. Sulfur mass independent fractionation (SMIF) preserved in sedimentary rocks happens:

A Only during “snowball Earth” events

B Only before the Late Heavy Bombardment

C Only when there is an active water cycle

D Periodically during global oxidation events

E Only before the rise of oxygen

31. Evidence that recent increases in concentrations of atmospheric CO2 are human induced includes:

A Decreases in the 13C/12C ratio of the atmosphere

B A decrease in the oxygen content of the atmosphere with rising CO2

C Mass balance with relative inputs of CO2 from burning of fossil fuels vs. volcanic emissions

D All of the above

E None of the above

32. Groundwater reservoirs recharge on timescales of similar length to:

A Seasonal cycles

B Weekly storms

C Glacial cycles

D Climate regulation by the tectonic thermostat

E All of the above

**Short answer questions: Answer 9 out of the following 10 questions. Keep your answers brief! Bullet points are encouraged where applicable. (20 points each) (180 points total)**

1. More than ten lines of evidence for plate tectonics were identified in the course. Name seven independent lines of evidence, and explain why movement of the plates is a fact and not a theory.

2. What is steady-state disequilibrium? Give an example of a system exhibiting steady-state disequilibrium. List three other characteristics of natural systems.

3. Draw and label the diagram illustrating the solid Earth plate tectonic cycle. Include as much detail as you can, and make the drawing reasonable (for example, do not have oceans thicker than plates).

4. Each of the following has significance for efforts to trace the history of the oxygenation of Earth’s surface. Explain when they formed, how they formed (briefly), and what they imply for the relative level of atmospheric oxygen: (a) Uraninite in gravels; (b) SMIF; (c) BIFs; (d) Red beds; (e) Multicellular life.

5. Four “energy revolutions” were discussed in the text. What is each of these revolutions, and over what intervals of Earth history did each occur?

6. Two methods for the discovery of planets around other stars were discussed in the text. What are these two methods, and how does each of them work? What types of planets are most easily discovered using these methods?

7. What are the four major steps envisaged for the origin of life? Explain (briefly) how two of them might have occurred.

8. Present three lines of evidence for evolution observable on human timescales.

9. Give the physical explanations and timescales of the three components of Milankovitch cycles. What effect have they had on Earth in the last several hundred thousand years, and in what two datasets are they observed?

10. Write a question you think should be worth 20 points and provide the answer to it.