Test #1

You will have 60 minutes to complete this test.

Multiple Choice (2 points each – 15 questions)

1. The "black-body" temperature of a planet (a) is set when the reradiated radiation equals the incoming radiation; (b) falls unless the incoming radiation exceeds the reradiated radiation; (c) continues to rise as long as there is incoming radiation; (d) is set only by the IR radiation coming from the parent star.
2. The tidal effects on a planet (a) decrease as the mass of the star increases; (b) decreases as the planet moves closer to the star; (c) increases with increasing distance from the star; (d) increases with decreasing mass of the star.
3. The existence of "ice ages" in the recent (few million years) past is believed in part to be due directly to (as in direct inputs into our ecosystem and climate): (a) changes in the energy output of the sun; (b) the rate of volcanic activity, and corresponding level of outgassing of CO_2 in the atmosphere; (c) the locations and sizes of the continents; (d) the precession of Earth's rotation axis and cyclic changes in Earth's orbital ellipticity.
4. The discovery of "hot Jovians" was surprising because (a) it was not surprising at all – planetary formation models predicted them; (b) these Jovians were all believed to be completely rocky (no gas) in nature; (c) these Jovian planets were orbiting around pulsars; (d) these Jovians were located in places where they could not have formed – the gasses that form them would not have been in solid form.
5. One of the properties of life are that (a) it is carbon-based, using liquid water as a solvent, in an oxygen atmosphere; (b) requires the preservation of its structure against thermodynamic degradation by consumption and reproduction or some other form of maintenance; (c) must evolve so as to fill all the available ecological niches; (d) requires a temperature much like ours in order to sustain itself.
6. The Drake Equation in the end (a) tells us how prevalent life is throughout the Universe; (b) describes how long life would have to exist on a planet in order to reach intelligence; (c) explicitly assumes that the development of intelligence requires bipedalism; (d) can tell us how far apart are various communicating civilizations from each other.
7. The detection of extrasolar planets can now be done reproducibly through; (a) the observation of planets occulting their parent star; (b) through time-lapsed observations of the motion of stars across the sky; (c) through direct detection of planets in the infrared, radio, or visible spectrum; (d) through an astrologer or other oracle, working with a divining rod.
8. The human eye detects visible light, it is believed, because (a) the material in our retinas can interact only with visible light; (b) it was purely an accident of evolution – some fish hundreds of millions of years ago had such eyes, and we are stuck with them; (c) they could see in other parts of the spectrum, but over time they devolved so that we can only see visible light; (d) the local environment, and most of the atmosphere, is transparent to visible light but opaque to other radiation.

9. The presence of Jupiter, and its gravity, in the outer solar system is believed to (a) stabilize Earth's orbit against huge changes in its orbital shape; (b) protect the Earth from interstellar radiation; (c) keep rocky asteroids in the inner solar system from striking the earth; (d) keep out nearly all the icy comets that would have struck the earth instead.
10. The birth of life on Earth is believed to have required (a) a heavily reducing atmosphere; (b) the sun to be much fainter than it is today; (c) the presence of organic materials from volcanoes or comets; (d) the presence of an ozone layer to protect the surface from UV radiation.
11. Titan, a moon of Saturn, is not believed to have life using water because (a) it has organic compounds of the wrong type for using water (its hydrocarbons are not soluble in water); (b) there is very little water on Titan's surface; (c) there is much more liquid ammonia than water in the atmosphere and surface; (d) water is a solid on Titan's surface.
12. Enzymes are a type of protein catalysts that act to (a) speed up reactions; (b) synthesize organic compounds alone; (c) reduce the degrees of freedom of two or more reactants by attaching to them; (d) (a) and (d)
13. The largest chunk of Earth's biological history took place in an (a) oxidizing atmosphere full of free oxygen; (b) the relatively quick development of multicelled, complicated organisms in Earth's history; (c) an anoxic (no free O_2), neutral or reducing atmosphere with single-celled organisms; (d) very cold atmosphere with sheets of ice spanning the globe.
14. The development of life was believed to be (a) the spontaneous arrangement of molecules until a group of them coalesced and became "living"; (b) a semi-continuous process from a chemical ecology of competing, complicated, self-replicating molecules to "life" (somehow); (c) a result of something like the Miller-Urey experiment – reducing compounds + water + energy -> life (eventually); (d) the stable accumulation of organic compounds, such as amino acids, in the oceans until life eventually appeared.
15. On the shortest time scales, carbon dioxide is removed from Earth's atmosphere by (a) the carbonate-silicate cycle; (b) by dissolving into Earth's oceans; (c) plants on land and in the sea; (d) the construction of homes made of wood.

True/False Questions (2 points each – 10 questions)

1. The development of intelligent life could only have occurred now, because the galaxy is not much older than the sun (T/F).
2. The sun lies within the middle of a galactic spiral arm (T/F).
3. The most recent ice age (evidence of large-scale shifts in the environment) took place tens of thousands of years ago (T/F).
4. It is believed that one of the biggest bottlenecks to evolution on our planet was the development of multicelled life from single-celled life (T/F).
5. Intelligent life can develop on stars much more massive than the sun (T/F).
6. The presence of carbon in the universe is very sensitive to small changes in nuclear parameters in stellar nuclear reactions (T/F).
7. The Hart model results in a very wide CHZ (continuously habitable zone) for our sun – on the order of 1 AU (T/F).
8. Since the sun has the density of water, therefore the sun is a liquid (T/F).
9. The composition of Europa is believed to be mostly solid and liquid water by mass (T/F).
10. There is about as much carbon dioxide in Earth's atmosphere as there is in Mars's atmosphere (T/F).

Essay Questions

1. (10 points) Give the main reasons in which stars are different from planets – that is, what distinguishes a star from a planet?

2. (20 points) Describe in some detail the 2 main methods for searching for planets, and simply define another method for detecting planets. Also, what was the first extrasolar planet discovered, and what makes it so special? According to the old theory of planet formation, how did the gas giants form – you should describe the model in sufficient detail that you can show why Jupiter and Saturn have different compositions and masses from Uranus and Neptune.\

3. (20 points) Describe the carbonate-silicate cycle, and show how this is a negative feedback loop by raising and then lowering the temperature initially. What happens to the atmospheric carbon dioxide in both cases (raising and lowering temperature)?

4. (10 points) Write down the simple (1961) Drake equation and describe all the terms in it.

Math Questions

1. (5 points) There are 500 civilizations spread out uniformly through the disk of our galaxy. Our galactic disk can be thought of as a sheet 45,000 light-years in radius. What is the average separation between civilizations? Remember the formula for areal number density σ and average separation ℓ, $\ell = \sigma^{-1/2}$.

2. (25 points) Now consider the question of the equilibrium sizes of GMCs (giant molecular clouds). The sizes of these clouds are determined by $G = 6.673\times10^{-11}\,\mathrm{kg^{-1}\,m^3\,s^{-2}}$, the mass density $\rho = 10^{-21}\,\mathrm{kg\,m^{-3}}$, and the local sound speed (taken with the temperature being 10 Kelvins), so that $c_s = 400\,\mathrm{m\,s^{-1}}$.
   a. (15 points) Using the prescription $G \equiv M^{-1}L^3T^{-2}$, $\rho \equiv ML^{-3}$, and $c_s \equiv LT^{-1}$, where M is a mass, L is a length, and T is a time, construct a length from these three variables using the prescription $R \equiv G^\alpha \rho^\beta c_s^\gamma$.

   b. (5 points) Using the above values of G, ρ, and c_s, calculate the radius R of this giant molecular cloud.

   c. (5 points) Using the mass density and assuming the cloud is a sphere, calculate the mass of the cloud (note that $M = \rho V$, where V is a volume and $V = \frac{4}{3}\pi R^3$ for a sphere).