

# Final Exam

(5/10/2007)

## Instructions

- A. Answer **ALL** questions on the optical scan page provided, using a #2 pencil.
- B. Make sure to include your **NAME** and **STUDENT ID**. The computer identifies you by your student ID; do not forget to include it.
- C. Do **NOT** mark your date of birth. Instead, use the first column of the day of the date of birth, to mark the **VERSION NUMBER(0 or 1)** as indicated above. This is **VERY IMPORTANT**, since different versions have different answers.
- D. The exam is **CLOSED BOOK**. You should not use any books or notes.
- E. Time: **2 HOURS AND 30 MINUTES**.

1. Which planet lies between the planets Saturn and Neptune?  
A) Uranus  
B) Pluto  
C) Mars  
D) Jupiter
2. A scientific model is considered valid if it is consistent with  
A) a single observation by an individual scientist  
B) the opinions of experts in the field  
C) repeated observations made by an individual scientist  
D) independent observations made by different scientists
3. One of the fundamental principles of stellar evolution is that the more massive a star is  
A) the more heavy elements it contains  
B) the more planets it has around it  
C) the faster it evolves  
D) the slower it evolves
4. The Cambrian Explosion began approximately  
A) 2.1 billion years ago  
B) 545 million years ago  
C) 360 million years ago  
D) 65 million years ago
5. Seafloor spreading on the Earth is the process by which  
A) volcanic material flows from the deep interior to produce volcanic islands  
B) dense material sank while lighter material rose to the surface during the early geological history  
C) molten lava oozes out between two tectonic plates that are slowly moving apart  
D) oceanic crust sinks below continental crust at a tectonic plate boundary

6. Which kind of robotic space mission enables us to determine the chemical composition of a solar system body in a laboratory?  
A) sample return  
B) flyby  
C) lander/probe  
D) orbiter
  
7. If we compress the entire history of the Earth into one year, life on Earth appeared  
A) in early February  
B) at the beginning of January  
C) in late December  
D) in late September
  
8. Which forms of life on Earth show the greatest diversity?  
A) insects  
B) human beings  
C) plants  
D) microbes
  
9. Which of the following signals from an advanced civilization would be easiest to detect?  
A) high intensity, narrow bandwidth  
B) low intensity, wide bandwidth  
C) high intensity, wide bandwidth  
D) low intensity, narrow bandwidth
  
10. What do we mean by the half-life of a radioactive isotope?  
A) it is the amount of time a person can be exposed to radiation without getting sick  
B) it is the time for half the number of radioactive nuclei to become stable nuclei  
C) it is the amount of time for half of the nuclei to become radioactive  
D) it is the time for half the number of radioactive nuclei to decay
  
11. In the nuclear fusion of four hydrogen nuclei to form a helium nucleus, the resultant helium nucleus  
A) is more massive than the four hydrogen nuclei, the missing mass being converted into energy  
B) is radioactive, generating energy by ejected electrons from beta decay  
C) is less massive than the four hydrogen nuclei, the missing mass being converted into energy  
D) has exactly the same mass as the four hydrogen nuclei, the energy being generated by the helium nucleus rearranging itself by emitting a gamma ray

12. Energy utilization in living organisms is
  - A) one of the most basic requirements of life, without which organisms could not maintain order, grow, and reproduce
  - B) only important for organisms like plants which receive their energy directly from the Sun
  - C) neither a necessary nor a sufficient condition for life
  - D) not important for organisms that have adapted to survive extremely low temperatures (psychrophiles)
  
13. Significant amounts of liquid water last existed on the surface of Mars during the
  - A) Noachian Era
  - B) Amazonian Era
  - C) Hadean Era
  - D) Hesperian Era
  
14. If you were to come back to Earth in 150 million years time, what would a map of the planet look like compared to today?
  - A) so completely different that none of our current continents would be recognizable
  - B) only slightly different because plate motion is extremely slow
  - C) exactly the same because plate tectonics is no longer occurring
  - D) quite different because plate tectonics would have caused a shift in the position of the continents
  
15. If we allow for moisture loss due to a moist greenhouse effect, the inner boundary of the Sun's habitable zone would be
  - A) just inside the orbit of the Earth
  - B) roughly halfway between the orbits of Venus and Mercury
  - C) roughly halfway between the orbits of the Earth and Venus
  - D) just outside the orbit of the planet Mercury
  
16. Why do we think that RNA was probably the first self-replicating molecule?
  - A) it is able to replicate at high temperatures found near deep-sea ocean vents
  - B) it is much simpler than DNA
  - C) in laboratory studies researchers have shown that it is able to catalyze its own replication
  - D) it is able to replicate using carbohydrates rather than proteins
  
17. Mercury and the Moon are probably the least-habitable bodies in the solar system because they
  - A) are unlikely to have liquids anywhere
  - B) have never had carbon compounds on their surfaces
  - C) do not have atmospheres containing oxygen
  - D) do not receive any sunlight

18. The light-year is defined to be the
- A) time it takes light to travel from the Sun to the Earth
  - B) time it takes for light to travel from the nearest star to the Earth
  - C) distance light travels in one year
  - D) average distance between the Earth and the nearest star
19. If our solar system hadn't formed with a Jupiter-sized planet,
- A) the Sun would have been more massive, with a lifetime too short for life to evolve
  - B) the Earth would have never formed
  - C) the rate of impacts on the Earth may have been much higher, possibly preventing the appearance of life
  - D) the rate of impacts on the Earth may have been much lower, enabling the appearance of life much earlier
20. The complete set of genetic information that makes up an organism is known as a
- A) genome
  - B) codon
  - C) chromosome
  - D) gene
21. When heat and pressure are applied to an igneous rock it turns into
- A) another sedimentary rock
  - B) an igneous rock
  - C) a meteorite
  - D) a metamorphic rock
22. During its descent into Titan's atmosphere, the *Huygens* probe found
- A) large oceans of liquid methane covering the entire surface
  - B) small pools of liquids directly beneath its descent path
  - C) a completely smooth, frozen surface with no sign that any liquids had ever been present
  - D) no sign of flowing or pooled liquids currently on the surface although channels carved in the past by fluids were seen
23. Aerobic organisms first started building up oxygen in the Earth's atmosphere around
- A) 4.6 billion years ago
  - B) 3.5 billion years ago
  - C) 4.0 billion years ago
  - D) 2.4 billion years ago
24. Which kind of interstellar spacecraft collects its fuel during its passage?
- A) interstellar ark
  - B) matter-antimatter rocket
  - C) solar sail
  - D) interstellar ramjet

25. How does the speed (in a vacuum) of a high-frequency electromagnetic wave compare with a low-frequency electromagnetic wave?
- A) the lower-frequency wave has the higher speed because speed is inversely related to frequency
  - B) the two waves have the same speed because the speed of light is constant
  - C) the lower-frequency wave has the higher speed because it has the longest wavelength
  - D) the higher-frequency wave has the higher speed
26. The basic molecular building blocks of proteins are
- A) nucleotides
  - B) fatty acids
  - C) amino acids
  - D) monosaccharides
27. According to optimistic estimates, the end of habitability of Earth will come about
- A) a few hundred thousand years from now
  - B) a billion years from now
  - C) 3 to 4 billion years from now
  - D) 100 million years from now
28. A habitable world is defined to be one that
- A) is identical to the Earth
  - B) is in orbit about a solar-type star
  - C) has an atmosphere
  - D) has conditions suitable for life
29. The most likely method of interstellar communication is similar to which type of communication on Earth?
- A) sign language
  - B) telepathy
  - C) Morse code
  - D) the spoken word
30. Most of the carbon dioxide on the Earth
- A) is dissolved in the oceans, forming carbonate rocks
  - B) has frozen out in the polar regions
  - C) has escaped into space
  - D) is still present in the atmosphere

31. The fact that the strength of gravity decreases with distance means the force of gravity exerted by one object on another (e.g., the Earth and Moon) is greater on the near side than the far side. This effect is commonly referred to as a
- A) tidal force
  - B) differential force
  - C) distortive force
  - D) tractive force
32. Which type of rock is the easiest to date radiometrically?
- A) sedimentary
  - B) all three types of rock are equally easy to date
  - C) metamorphic
  - D) igneous
33. Kepler's First Law of planetary motion states that
- A) an imaginary line joining the Sun and planet sweeps out equal areas in equal times
  - B) the further a planet is from the Sun, the faster it moves in its orbit
  - C) the orbits of planets are ellipses
  - D) the further a planet is from the Sun, the slower it moves in its orbit
34. Compared to the Earth, Mars has experienced wild swings in its axis tilt over relatively short time periods. This is because of its
- A) proximity to Jupiter and its lack of a large moon
  - B) greater distance from the Sun
  - C) slower rotation rate
  - D) small size
35. What is the most compelling piece of evidence that suggests that the dinosaurs were made extinct by the impact of an asteroid 65 million years ago?
- A) a layer of sediment laid down at that time which is littered with dinosaur fossils
  - B) dinosaur fossils are found in rock layers older than 65 million years but not younger than 65 million years
  - C) a layer of sediment laid down at that time which is rich in the element Iridium (Ir), an element common in asteroids but less common on the Earth
  - D) the crater from this impact can still be seen in the deserts of Arizona
36. If a star has an extrasolar planet, the symmetry of its radial velocity curve is related to the planet's
- A) orbital shape
  - B) mass
  - C) radius
  - D) orbital period

37. Between the orbits of the planets Mars and Jupiter we find
- A) the Oort cloud
  - B) Orion's belt
  - C) the Kuiper belt
  - D) the asteroid belt
38. The Luyten 726-8 binary system is approximately 9 light-years away. If we send a spacecraft to visit this system traveling at 90% of the speed of light, how long will a one-way trip take as measured from the Earth?
- A) it's impossible to tell unless we know the spacecraft's method of propulsion
  - B) more than 10 years
  - C) 10 years
  - D) less than 10 years
39. Bacteria are examples of
- A) unicellular prokaryotes
  - B) unicellular eukaryotes
  - C) multicellular eukaryotes
  - D) multicellular prokaryotes
40. One observation that suggests that the Earth has a dense central core is that
- A) the Earth has plate tectonics
  - B) surface rocks have the same density as the overall density of the planet
  - C) surface rocks have a lower density than overall density of the planet
  - D) surface rocks have a higher density than the overall density of the planet
41. Intelligence may be subject to convergent evolution because it
- A) is inevitable
  - B) is a fundamental characteristic of life
  - C) has survival value
  - D) is required for survival
42. The Mars Exploration Rovers, *Spirit* and *Opportunity*, are examples of which kind of spacecraft?
- A) flybys
  - B) sample return
  - C) landers
  - D) orbiters
43. The greenhouse effect is the
- A) generation of heat in the outer layer of the Earth's atmosphere due to absorption of short wavelength radiation
  - B) generation of heat in the ozone layer due to the absorption of ultraviolet radiation
  - C) release of heat by volcanism along tectonic plate boundaries
  - D) trapping of infrared radiation from the Earth's surface by greenhouse gases like carbon dioxide, methane, and water

44. A sample of an ancient sedimentary rock contains slightly less of the isotope carbon-13 than normal. One possible explanation for this is that
- A) it was a meteorite that fell from the sky
  - B) some kind of radioactive decay occurred in it in the past
  - C) it used to be at the bottom of an ancient ocean
  - D) some kind of biological activity occurred in it in the past
45. Most likely, oxygen was first released into the atmosphere by
- A) the decomposition of dead organisms
  - B) plants
  - C) cyanobacteria
  - D) oxidation reactions
46. In the scientific method, what immediately follows a prediction?
- A) a hypothesis
  - B) an observation
  - C) a question
  - D) a test
47. During winter, the northern polar cap of Mars is made of
- A) a layer of carbon dioxide ice
  - B) a layer of water ice
  - C) carbon dioxide ice overlaying water ice
  - D) water ice overlaying carbon dioxide ice
48. As life on Earth evolved, its DNA
- A) changed gradually into RNA
  - B) stayed the same
  - C) became gradually less complex
  - D) became gradually more complex
49. Most of the extrasolar planets detected to date are found
- A) at about the same distance as the Earth is from the Sun
  - B) very close to the parent stars
  - C) at about the same distance as the planet Jupiter is from the Sun
  - D) very far from their parent stars
50. A fossil is found in a layer of strata above one layer dated at 2 million years. From this we can deduce the age of the fossil to be
- A) we can tell nothing about the fossil's age from this data
  - B) younger than 2 million years
  - C) between 2 and 3 million years old
  - D) older than 3 million years

51. Around 4 billion years ago Venus could have been more Earth-like with liquid water on its surface because
- A) Venus has a protective magnetic field
  - B) its atmosphere was thinner
  - C) Venus was farther from the Sun
  - D) the Sun was dimmer so Venus would have received less radiation
52. Any change in the base sequence of an organism's DNA is referred to as a
- A) malformation
  - B) transmutation
  - C) distortion
  - D) mutation
53. A probe placed in orbit about Europa would be able to confirm the presence of a subsurface ocean using a
- A) spectrometer to detect the spectral signature of liquid water at and beneath the surface
  - B) camera to observe the formation and breakup of icebergs on the surface
  - C) projectile to break the thin icy crust to reveal the water below
  - D) laser altimeter to detect the regular bulging of the thin icy crust on top of the ocean due to tidal forces
54. Which of the following are possible causes for mass extinctions on Earth?
- A) gamma ray bursts and supernova explosions
  - B) episodes of widespread volcanism
  - C) magnetic field reversals
  - D) all of these can be responsible for mass extinctions
55. For most of human history it was believed that Earth was at the center of the universe. This idea is referred to as
- A) geocentric
  - B) eccentric
  - C) heliocentric
  - D) egocentric
56. In the outer regions of the solar nebula where temperatures were low,
- A) only rock and iron could condense
  - B) only hydrogen compounds could condense as ices
  - C) hydrogen and helium gases were able to condense
  - D) in addition to rock and iron, hydrogen compounds also condensed as ices

57. Which of the following statements is an overall summary of the findings from the *Viking* biology experiments?
- A) the martial soil showed no signs of chemical or biological activity
  - B) the Martian soil showed clear signs of biological activity
  - C) the Martian soil is chemically reactive but shows no signs of biological activity
  - D) the Martian soil contained organic molecules but showed no signs of biological activity
58. Why can't the carbon dioxide cycle easily correct for the increasing amounts of carbon dioxide introduced into our atmosphere by industrialization?
- A) it operates far too slowly to correct for any short-term changes
  - B) pollution has stopped the carbon dioxide cycle from operating
  - C) the carbon dioxide cycle only influences carbon dioxide produced by natural sources
  - D) it operates far too quickly to correct for any short-term changes
59. The basic biological structures of life on Earth are called
- A) cells
  - B) bacteria
  - C) molecules
  - D) atoms
60. Brown dwarfs are
- A) stars in the process of forming
  - B) very cool, main-sequence stars of spectral type M
  - C) the burnt out cores of dead stars
  - D) objects with insufficient mass to sustain nuclear fusion in their cores
61. You are traveling in a space ship at half the speed of light ( $0.5c$ ) directly toward an oncoming photon traveling at the speed of light ( $c$ ). At what speed would you see the photon coming toward you?
- A)  $c$
  - B)  $0.25c$
  - C)  $1.5c$
  - D)  $0.5c$
62. What was one reason that RNA was eventually replaced by DNA as the molecule of choice for storing genetic information?
- A) the bases that make up DNA became much more common
  - B) DNA is far more stable than RNA
  - C) DNA can catalyze its own replication
  - D) the double helix of DNA is better able to correct errors in replication

63. Rocks are found on the surface of another planet which appear to have been formed from the solidification of molten lava. Given this, they are most likely to be classified as
- A) meteoritic
  - B) metamorphic
  - C) sedimentary
  - D) igneous
64. In the mid-1970s, the *Viking 1* orbiter discovered a feature in the Cydonia region of Mars which resembled a human face. What is the currently accepted scientific explanation for this feature?
- A) it is a small volcano on the surface of the planet that simply looked like a face using the low-resolution cameras installed on Viking
  - B) it is a natural hill-like feature that simply looked like a face using the low-resolution cameras installed on *Viking*
  - C) the feature was added by NASA scientists to the *Viking* image as a joke
  - D) it is a monolith left by an ancient Martian civilization
65. An optical SETI signal would most likely consist of
- A) using mirrors to reflect light from the surface of a planet
  - B) using a giant disk to block out the light from the parent star
  - C) rapid, short bursts of intense laser light
  - D) a continuous beam of laser light
66. A chemoautotroph gets its energy from
- A) chemical reactions and its carbon from its environment
  - B) the Sun and its carbon from other organisms
  - C) chemical reactions and its carbon from other organisms
  - D) the Sun and its carbon from its environment
67. What is the most intriguing piece of evidence that suggests that the Martian meteorite ALH84001 may have once contained life?
- A) molecules of DNA were found inside
  - B) oxygen gas was found trapped inside the meteorite
  - C) amino acids were found inside
  - D) highly magnified images of carbonate grains found inside reveal rod-shaped structures that look much like terrestrial nanobacteria
68. Some Jovian moons may have liquid water
- A) beneath their surfaces
  - B) at their centers
  - C) on their surfaces
  - D) in their atmospheres

69. According to current astronomical data, approximately how old is the universe?
- A) 65 million years
  - B) 6000 years
  - C) 4.6 billion years
  - D) 14 billion years
70. As global warming raises the moisture content in our atmosphere, storms will
- A) become less numerous and less severe
  - B) disappear all together
  - C) become less numerous but more severe
  - D) become more numerous and severe
71. Endospores are
- A) fossilized organisms found inside meteorites
  - B) organisms that embed themselves inside other cells
  - C) dormant or resting cells formed by certain organisms that are able to survive extreme conditions
  - D) organisms which that live beneath Earth's crust
72. Which of the following methods has been the LEAST successful in detecting extrasolar planets around other star systems?
- A) regular changes in the positions of the parent stars with respect to more distant stars as they move across the sky
  - B) detection of Doppler shifts in the spectra of the parent stars
  - C) detection of brightness changes in a star as a planet passes in front of it
  - D) detection of reflected starlight
73. In chemistry, oxidation occurs when a substance
- A) loses electrons
  - B) rearranges its electrons internally
  - C) accepts electrons
  - D) breaks into its constituent atoms
74. Life on Earth can use a variety of different carbon and energy sources. However, the one thing that no organism on Earth can survive without is
- A) water in any form: solid, liquid, or gas
  - B) oxygen
  - C) a liquid solvent of any kind
  - D) liquid water
75. The discovery of four moons in orbit about Jupiter by Galileo suggested that
- A) the Earth moved about Jupiter
  - B) the Earth moved about the Sun
  - C) Jupiter moved about the Sun
  - D) bodies could stay in orbit about a moving Jupiter

76. When electromagnetic radiation is created it is said to be
- A) reflected
  - B) emitted
  - C) refracted
  - D) absorbed
77. Which is the most common type of spacecraft propulsion used today?
- A) solar sails
  - B) nuclear rockets
  - C) ion engines
  - D) chemical rockets
78. In which eon of Earth's history did the early bombardment occur?
- A) Hadean
  - B) Archaen
  - C) Phanerozoic
  - D) Proterozoic
79. The process by which molecules escape from a solid directly into the gas phase is called
- A) gasification
  - B) evaporation
  - C) condensation
  - D) sublimation
80. Even though ethane ( $C_2H_6$ ) has a liquid temperature range almost as wide as water, it is not as good a biological solvent as water because it is a liquid at
- A) much higher temperatures which would result in the breakdown of fragile biological molecules
  - B) very high pressures that are unlikely to be found elsewhere
  - C) very low pressures that are unlikely to be found elsewhere
  - D) much lower temperatures which would result in extremely slow metabolic reactions
81. The dark maria on the moon are
- A) layers of dark meteoritic debris from impacts
  - B) layers of darker rock just beneath the surface which have been uncovered by impacts
  - C) huge impact basins filled in by lava flows
  - D) oceans of liquid water covering the surface

82. Why might we think that silicon would be an obvious alternative to carbon as a building block for biological molecules?
- A) it forms the basis of some life forms on Earth
  - B) it has a similar abundance on Earth to carbon
  - C) it forms complex molecules like carbon
  - D) it has a similar electronic structure to carbon, forming a maximum of four bonds and, hence, should have a similar chemistry
83. The number of impact craters on the slopes of Tharsis volcanoes suggests that they have been inactive
- A) since Mars formed 4.6 billion years ago
  - B) for at least a billion years
  - C) for at least tens of millions of years
  - D) only for the last few hundred years
84. Most of the carbon dioxide on Venus
- A) is trapped beneath the surface of the planet in gaseous form
  - B) has escaped into space
  - C) is present in its atmosphere
  - D) is locked up in carbonate rocks in its crust
85. A radioactive isotope with an atomic number of 92 undergoes alpha decay. What is the atomic number of the daughter nucleus?
- A) 93
  - B) 90
  - C) 91
  - D) 94
86. According to our current theory of planet formation, can a Jupiter-like planet form from a rotating disk of dust and gas close to its parent star?
- A) no, because the gases would be attracted to rocky terrestrial planets, forming atmospheres
  - B) yes, because we see Jupiter-like planets with small orbits around other stars
  - C) no, because it would be too hot for gases to condense
  - D) no, because there is no gas, only rock in the inner part of the disk
87. The earliest *Homo sapiens* appeared about
- A) 25 million years ago
  - B) 6 to 8 million years ago
  - C) 100,000 years ago
  - D) 545 million years ago

88. What is the main factor that drives Darwinian evolution?  
A) the competition for finite resources  
B) the need to have sex  
C) the ability of an organism to harness the energy of the Sun  
D) the size of an organism
89. The Ptolemaic model has planets moving in  
A) elliptical orbits about the Sun  
B) a simple circle about the Earth  
C) a simple circle about the Sun  
D) small circles, the centers of which move in a larger circle about the Earth
90. White dwarfs  
A) are dead stars  
B) are in the process of forming  
C) are mature stars that are fusing hydrogen into helium in their cores  
D) have exhausted their nuclear fuel and are in the process of dying
91. Which of the four Galilean moons is LEAST likely to harbor life beneath its surface?  
A) Europa  
B) Io  
C) Callisto  
D) Ganymede
92. Isotopes have the same number of  
A) protons and neutrons  
B) protons but a different number of electrons  
C) neutrons but a different number of protons  
D) protons but a different number of neutrons
93. O-type stars  
A) have lifetimes long enough for advanced life to evolve  
B) have lifetimes long enough for planets to form and for life to appear, but not long enough for advanced life  
C) do not contain enough heavy elements to form planets  
D) have lifetimes too short for planet formation
94. What are the relative ages of the heavily cratered Southern highlands and the smooth Northern plains of Mars?  
A) the highlands and the plains are the same age  
B) it is impossible to tell unless we know the specific geological processes that occurred in each hemisphere  
C) the plains are older than the highlands  
D) the highlands are older than the plains

95. After World War II, the U.S. Government spent two decades investigating UFOs because they
- A) were themselves developing new types of aircraft and used the official investigation as a cover-up
  - B) thought that they might be new types of aircraft being developed by the Soviet Union
  - C) knew that UFOs were alien craft and used the official investigation as a cover-up
  - D) were afraid that an alien civilization was in the process of invading the Earth
96. Isotopic analysis of meteorites suggests the Earth and the rest of the solar system formed
- A) 3.85 billion years ago
  - B) 4.57 billion years ago
  - C) 4.4 billion years ago
  - D) 4.0 billion years ago
97. Encephalization Quotient (EQ) values can be estimated for extinct species because
- A) there is a linear relationship between the EQ and time, thus allowing extrapolation
  - B) extinct species always have the same EQ value
  - C) we can estimate their body masses from their fossilized remains and their brain masses from the sizes of their fossilized cranial cavities
  - D) we can always find similar species in existence today to make measurements of
98. To date, meteorites have been identified originating from which planets and moons?
- A) Mars only
  - B) All terrestrial planets
  - C) The Moon and Mars
  - D) The Moon only
99. The FEW extrasolar planets that have been detected DIRECTLY to date are
- A) very large and at great distances from their parent star
  - B) small and at great distances from their parent star
  - C) small and close to their parent star
  - D) very large and close to their parent star
100. If we imagine that 1 in 10 million stars would eventually give rise to a civilization on an orbiting planet and assuming that there are 100 billion stars in our Milky Way galaxy, how often should a civilization randomly appear over a 5 billion year period?
- A) once every 50 million years
  - B) once every 50,000 years
  - C) once every 500,000 years
  - D) once every 5 million years