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Student ID# \_\_\_\_\_

## OCEANOGRAPHY 201

Fall, 2002

Exam #1: Section #1

Answer 1-60 on the computer-scan sheet (1 point each). Use a dark (#2) pencil only, and make marks neatly within the circles. If you change an answer, erase completely. Also, be sure your ID number is coded correctly.

### **PART 1: True/False (1 point each = 20 points). Mark (a) for "true" and (b) for "false".**

1. An informal rule in science is that extraordinary hypotheses require extraordinary evidence.
2. Latitude can be told from the declination of the Pole Star, whereas longitude requires an accurate clock.
3. The four inner planets are relatively richer in volatile elements and compounds than are the four outer gas-giant planets.
4. Earth is believed to have originated by accretion from planetesimals.
5. An hypsometric curve shows two levels on Earth, implying two kinds of crust, and only one on Venus.
6. The age of the Earth is indistinguishable from that of the Moon and meteorites: about 4.5 billion years.
7. Oceans of liquid water are common in our Solar System.
8. Free oxygen has always been an important component of the Earth's atmosphere.
9. The oldest rocks from the seafloor are much older than the oldest rocks from the continents.
10. Sea level changes have been modest throughout Earth's history, never exceeding more than about 10 m up or down.
11. Because seismic S-waves do not travel through liquids, the s-wave shadow zone indicates that at least part of the Earth's core is molten.
12. The lithosphere includes both the crust and part of the upper mantle.
13. The lithosphere is rigid and brittle, whereas the asthenosphere is plastic and ductile.

14. Hotspots can occur both at plate boundaries and in the middle of plates, and both in the oceans and on the continents.
15. The Hawaiian Islands are an example of island arc volcanism.
16. The Earth's mantle is entirely molten.
17. On the island of Oahu, sea level is falling at present.
18. Beaches are normally very stable in shape and width unless disturbed by human activities.
19. Seawalls are usually effective in preventing beach erosion.
20. The deep sea is a promising place to explore for oil and gas.

**PART 2: Multiple Choice (1 point each = 40 points).**

21. The scientific method involves
  - a) making observations.
  - b) asking questions.
  - c) formulating hypotheses.
  - d) making and testing predictions.
  - e) all of the above.
22. If the Sun is overhead two hours later than at some fixed point to the east of you, how many degrees are you to the west of this position?
  - a) 5°
  - b) 15°
  - c) 20°
  - d) 25°
  - e) 30°
23. Which of the following processes characterizes the interior of the Sun?
  - a) infall of iron under the influence of gravity.
  - b) outgassing of volatile elements and compounds.
  - c) reaction of a rocky mantle with an iron core.
  - d) a runaway greenhouse effect.
  - e) nuclear fusion of two hydrogen atoms to form helium
24. Four elements make up 93% of Earth's mass. They are
  - a) iron, oxygen, silicon, and magnesium.
  - b) iron, oxygen, magnesium, and hydrogen.
  - c) hydrogen, helium, nitrogen, and oxygen.
  - d) iron, nickel, calcium, and aluminum.
  - e) oxygen, nitrogen, carbon dioxide, and water vapor.
25. The process of large-scale chemical differentiation of the Earth has produced
  - a) the Earth's core.
  - b) continental and oceanic crust.
  - c) the oceans.
  - d) the atmosphere.
  - e) all of the above.

26. Processes that caused large-scale chemical differentiation of the Earth include
- a) a supernova explosion in a distant galaxy.
  - b) bombardment by cosmic rays originating from an unknown source.
  - c) separation of volatile elements and compounds from refractory elements and compounds.
  - d) separation of dense materials from less dense materials by gravity stratification.
  - e) both c) and d).
27. Which of the following theories for origin of Earth's Moon *cannot* be dismissed on dynamical or chemical grounds?
- a) gravitational capture of a large planetesimal.
  - b) fission due to rapid rotation.
  - c) impact by a large planetesimal, about the size of Mars, which blasted off material that then coalesced to form the Moon.
  - d) formation in the same manner as Earth, by accretion.
  - e) condensation from the Solar nebula.
28. Unlike the other planets, the Earth has oceans of liquid water. This is because
- a) Earth formed originally from a water-rich comet.
  - b) Earth inherited a primitive, water-rich atmosphere from the Solar nebula, which condensed into oceans as the Earth's surface cooled.
  - c) Earth formed rapidly from cold, water-rich planetesimals, and this water subsequently outgassed from Earth's interior.
  - d) Earth is the proper distance from the Sun, such that water can exist in the liquid state.
  - e) both c) and d).
29. Free oxygen in the Earth's atmosphere has been produced mainly by
- a) photodissociation of water and loss of hydrogen to outer space.
  - b) change in sea level.
  - c) formation of the Earth's core.
  - d) photosynthesis and burial of organic carbon.
  - e) nucleosynthesis in stars.
30. A "runaway greenhouse" refers to
- a) what happened on Mars.
  - b) what happened on Venus.
  - c) a process involving a positive feedback between the amount of carbon dioxide in a planetary atmosphere and the temperature of that atmosphere.
  - d) both b) and c)
  - e) all of the above.

31. Carbon dioxide that has outgassed from Venus resides mainly in Venus's atmosphere, where it has caused a runaway greenhouse effect. On Earth, carbon dioxide is mainly
- in rocks, as  $\text{CaCO}_3$  in limestone.
  - dissolved in the oceans.
  - tied up as organic matter in soils.
  - stored in coral reefs.
  - stored in deep-sea sediments.
32. The *major* cause of the *largest* worldwide changes in sea level known in the geologic record is
- change in the volume of ice stored on land.
  - change in the rate of seafloor spreading, which produces a change in the volume of the ocean basins.
  - local, tectonically induced vertical motions of the crust.
  - change in the temperature of ocean water.
  - storm surges.
33. A record of Earth's history going back nearly 4 billion years can be found
- in deep-sea sediments
  - in the ocean basins
  - on the continents
  - in subduction zones
  - all of the above.
34. The simplified reaction  $\text{CO}_2 + \text{H}_2\text{O} = \text{CH}_2\text{O} + \text{O}_2$  represents:
- photodissociation
  - chemical weathering
  - photosynthesis
  - none of the above
  - all of the above.
35. The simplified reaction  $\text{H}_2\text{O} + \text{CO}_2 + \text{CaSiO}_3 = \text{CaCO}_3 + \text{SiO}_2 + \text{H}_2\text{O}$  represents
- weathering of silicate rocks by rain water and removal of  $\text{CO}_2$  from the atmosphere into rocks.
  - photosynthesis followed by burial of some of the organic material produced.
  - the reaction by which the Earth's core formed.
  - The reaction that generates energy within the Sun and similar stars.
  - the formation of evaporite deposits that can form salt domes and trap oil and gas.
36. From outside to inside, the Earth consists of
- rocky crust, brittle lithosphere, plastic asthenosphere, solid metal outer core, liquid metal inner core.
  - rocky crust, rocky mantle, liquid metal outer core, solid metal inner core.
  - rocky crust, liquid mantle, plastic asthenosphere, solid outer core, solid inner core.
  - rocky crust, liquid asthenosphere, plastic mantle, liquid outer core, solid inner core.
  - none of the above.

37. Evidence that the Earth has two kinds of crust comes from
- a) seismology.
  - b) the hypsometric curve that plots Earth surface area against its elevation.
  - c) the Moon.
  - d) both a) and b).
  - e) all of the above.
38. The principal of isostasy states that
- a) the Earth's surface is dominated by two levels: the continents and the oceans.
  - b) the lithosphere is in gravitational equilibrium through a buoyancy mechanism, with compensation occurring in the asthenosphere.
  - c) crust is produced by differentiation from the mantle, by upwelling and solidification of molten rock.
  - d) if the Earth were perfectly smooth, it would be covered by nearly 3000 m of ocean water.
  - e) 25% of the continental crust presently lies below sea level.
39. According to the Geodynamo theory, the Earth's magnetic field originates from
- a) a bar magnet at the center of the Earth.
  - b) the Solar wind.
  - c) cosmic rays bombarding the upper atmosphere.
  - d) convection currents within the Earth's outer, liquid iron core.
  - e) outgassing of the planet and formation of the core.
40. The Earth has dry land because
- a) there is not enough water to cover the surface completely.
  - b) all planets have dry land.
  - c) it has continental crust, which rides isostatically higher than oceanic crust because it is relatively thick and less dense.
  - d) sea level has dropped throughout Earth history.
  - e) the mid-ocean ridges push up the bottom of the seafloor, as if it were a large plastic bowl.
41. Which of the following statements correctly describes crustal formation?
- a) Continental crust is created by wet melting of the mantle in subduction zones to produce andesite, whereas oceanic crust is formed by dry melting at mid-ocean ridges to form basalt.
  - b) Continental crust is created by erosion in mountain belts, whereas oceanic crust is created from deep-sea sediments.
  - c) Continental crust is formed above sea level, whereas oceanic crust is formed below the carbonate compensation depth.
  - d) Continental crust is formed on cratons, whereas oceanic crust is formed in mobile belts
  - e) None of the above.

42. Continents are built by
- andesitic volcanism at subduction zones.
  - basaltic volcanism at mid-ocean ridges.
  - accretion of exotic terranes onto their margins.
  - outgassing of volatiles from the Earth's interior.
  - both a and c.
43. Continental drift theory experienced a revival in the 1950's as a result of new evidence that
- animals had crossed from Africa to South America via land bridges.
  - the Earth's magnetic poles had apparently wandered through time, but the paths inferred were different for different continents.
  - the Earth's magnetic field had reversed polarity repeatedly in the past.
  - the Earth was rotating on its axis, which corresponds to the geographic and magnetic poles.
  - all of the above.
44. The continents drift because
- they "plow through" the ocean basins in response to "polflucht".
  - of convection in the Earth's outer core.
  - they ride passively on the lithospheric plates, which are moving relative to one another and the mantle.
  - the Earth's magnetic field reverses its polarity.
  - all of the above.
45. The three main geologic settings on Earth where active volcanoes occur are
- abyssal plains, abyssal hills, and continental margins.
  - Hawaii, Iceland, and the Andes.
  - mid-ocean ridges, subduction zones, and hotspots.
  - convergent, divergent, and conservative plate boundaries.
  - Indonesia, Japan, and Bolivia.
46. Which of the following represents the extraordinary evidence that convinced geologists that the outrageous hypothesis of seafloor spreading was correct?
- the elevated topography of mid-ocean ridges.
  - absence of sediment along the mid-ocean ridge axis.
  - evidence for earthquakes and volcanism along the mid-ocean ridge axis.
  - magnetic stripes on the seafloor that were symmetrical on either side of the mid-ocean ridge axis and which could be correlated globally.
  - a valley along the mid-ocean ridge axis, formed by normal faulting and extension.
47. A major *prediction* of the seafloor spreading hypothesis that was made and tested is
- that there are magnetic stripes on the ocean floor.
  - that it could cause sea level change.
  - that the age of the seafloor increases with distance from the ridge on either side.
  - that the Earth's magnetic field originates by convection in the outer core.
  - that the Earth's magnetic field reverses its polarity.

48. The theory of plate tectonics
- a) is a unifying theory for the Earth sciences.
  - b) holds that the Earth's surface consists of a dozen or so rigid plates.
  - c) holds that most mountain-building occurs along plate boundaries.
  - d) holds that the lithospheric plates ride on the asthenosphere.
  - e) all of the above.
49. The three major types of plate boundaries are
- a) conservative, transform, slipslide.
  - b) continental-continental, oceanic-oceanic, continental-oceanic.
  - c) divergent, convergent, conservative.
  - d) constructive, destructive, conservative.
  - e) both c) and d).
50. Which of the following terms consistently describe a subduction zone?
- a) shallow earthquakes, basaltic volcanism, young crust, sediment absent to thin
  - b) shallow earthquakes, andesitic volcanism, young crust, thick sediment
  - c) shallow to deep earthquakes, andesitic volcanism, older crust, thick sediment
  - d) shallow to deep earthquakes, basaltic volcanism, older crust, thin sediment
  - e) no earthquakes, no volcanism, older crust, thick sediment
51. Which of the following is a “rule” of plate tectonics?
- a) Oceanic crust is too thick and buoyant to be subducted.
  - b) The volcanic arc always forms on the upper surface of the subducting plate.
  - c) When continents collide with one another they tend to “stick”.
  - d) The major process driving the plates is convection in the Earth’s outer core.
  - e) All of the above.
52. Continent-continent collisions
- a) result when the ocean basin between them is consumed by subduction.
  - b) cause the crust to thicken locally, as continental crust is too thick and buoyant to subduct.
  - c) cause the subducting lithospheric slab to break off, after which it continues to descend on its own.
  - d) can cause a reorganization of plate motions.
  - e) all of the above.
53. The main theory that explains hotspots is
- a) the shrinking Earth
  - b) seafloor spreading
  - c) continental drift
  - d) plate tectonics
  - e) mantle plumes.
54. The Hawaiian-Emperor seamount chain is an example of
- a) a fracture zone
  - b) a hot-spot trace
  - c) a mid-ocean ridge
  - d) a volcanic arc
  - e) a subduction zone.

55. Most of the sediment in the oceans, by volume, is deposited
- a) by organisms that have calcareous skeletons.
  - b) by organisms that have siliceous skeletons.
  - c) in the deep-sea trenches.
  - d) along the margins of the continents.
  - e) by andesitic volcanoes.
56. The carbonate compensation depth, or CCD, is
- a) the depth at which calcium carbonate dissolves in the oceans.
  - b) the depth at which calcium carbonate sediment is replaced by siliceous ooze.
  - c) the depth at any point in the oceans where the rate of delivery of calcium carbonate is equal to the rate at which it dissolves.
  - d) the depth above which calcium carbonate can accumulate, and below which it cannot.
  - e) both c) and d).
57. Longshore drift is
- a) a special case of continental drift theory.
  - b) a current that can carry swimmers offshore.
  - c) a process that results in formation of a delta.
  - d) a process that transports sand and other sediment along the coast.
  - e) movement of sand by tidal action.
58. The major long-term cause of coastal erosion is
- a) failure of politicians to plan ahead.
  - b) sea level rise.
  - c) beach loss.
  - d) building of sea walls and groins.
  - e) continental drift.
59. According to the State Constitution of Hawaii, beaches in Hawaii belong to
- a) the state government.
  - b) the people of Hawaii.
  - c) private landowners.
  - d) the Bishop Estate.
  - e) the Native Hawaiians.
60. The most valuable mineral material recovered from the seafloor today is
- a) gold and silver.
  - b) manganese nodules.
  - c) oil and gas.
  - d) sand and gravel.
  - e) phosphorites for fertilizer.

**PART 3: Short-Answer Essay Questions (total of 15 points).**  
**Please write your answers in the space below each question.**

61. Describe the “tape recorder” model and how it confirmed the hypothesis of seafloor spreading by answering the following questions **(10 points)**:

a) What was measured?

b) What global Earth process generated the pattern in the first place?

c) What two unusual properties did the pattern possess?

d) Why did Earth scientists find this evidence so convincing?

e) What major prediction was made by the seafloor spreading hypothesis that was subsequently tested and found to be true?

62. Explain how seawalls cause beach loss. **(5 points)**

**Fall 2002: Answers to selected essay questions:**

**Section 2:**

61. Earth's atmosphere is composed mainly of nitrogen and oxygen, whereas those of Venus and Mars are composed mainly of carbon dioxide. Also, Earth has abundant water in its oceans, whereas Mars and Venus do not. **(10 points)**

- a) Where is most of the CO<sub>2</sub> on Earth?
- b) Where is most of the nitrogen on Venus?
- c) What happened to the nitrogen on Mars?
- d) What happened to the water on Venus?
- e) Where is most of the water on Mars?

Answers:

- a) in rocks, as CaCO<sub>3</sub> in limestones
- b) in the atmosphere, but heavily diluted by carbon dioxide
- c) It was lost to outer space, because Mars is too small to hold it.
- d) Because of the high temperature of Venus's atmosphere, its water split into hydrogen and oxygen in the upper atmosphere. The hydrogen was lost to outer space and the oxygen reacted to oxidize rocks at the planet's surface.
- e) It is frozen at the poles and in the Martian soil.

**Section 1:**

61. Describe the "tape recorder" model and how it confirmed the hypothesis of seafloor spreading. It may help to answer the following questions **(10 points)**:

- a) What was measured?
- b) What generated the signal in the first place?
- c) What two unusual properties did the signal possess?
- d) Why did Earth scientists find this evidence so convincing?
- e) What major prediction was made by the seafloor spreading hypothesis that was subsequently tested and found to be true?

Answers:

- a) (residual) magnetic anomalies (or spikes, or stripes) on the seafloor
- b) reversal in polarity of the Earth's magnetic field
- c) It was symmetrical on either side of the mid-ocean ridge axis and it was the same for all mid-ocean ridge segments throughout the world (i.e., it was globally correlatable).
- d) The patterns were so specific that it was hard to explain them any other way.
- e) That the seafloor would increase regularly with age on either side of the mid-ocean ridge axis.