

Last Name _____ First Name _____

Student ID# _____

OCEANOGRAPHY 201

Fall, 2005

Exam #2: Section #2

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. The four inner planets are relatively richer in volatile elements and compounds than are the four outer gas-giant planets.
3. Earth contains elements that were formed in a supernova explosion.
4. Earth is believed to have originated by accretion from planetesimals.
5. The age of the Earth is indistinguishable from that of the Moon and meteorites: about 4.5 billion years.
6. Free oxygen was abundant in the Earth's early atmosphere.
7. An hypsometric curve shows two levels on Earth, implying two kinds of crust, and only one on Venus.
8. Earth's crust originated by solidification of molten rock that rose up from the mantle.
9. The continental crust is much thicker than the lithosphere.
10. 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.
11. The amount of land exposed above sea level has remained about the same for the last 600 million years.
12. The oldest rocks from the seafloor are much younger than the oldest rocks from the continents.
13. Sea level changes have been modest throughout Earth's history, never exceeding more than about 10 m up or down.

14. The lithosphere is rigid and brittle, whereas the asthenosphere is plastic and ductile.
15. Hotspots can occur both at plate boundaries and in the middle of plates, and both in the oceans and on the continents.
16. The Hawaiian Islands have formed along an active plate boundary.
17. The Earth's mantle is entirely molten.
18. Worldwide, sea level is falling today.
19. Beaches are normally very stable in shape and width unless disturbed by human activities.
20. Seawalls are usually effective in preventing beach erosion.

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

21. The element gold is formed a) in the centre of the Earth. b) during fusion in our Sun.
 c) during supernova explosions. d) all of the above.

22. The Sun's energy comes from a) gravity b) nuclear fusion c) red-shifting
 d) parallax e) chemical differentiation.

23. 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.

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. Chemical differentiation refers to
a) the sum of large-scale chemical and physical processes that separate material based on its chemistry.
b) the processes that formed Earth's core, mantle, and crust.
c) the processes that separated material that became the inner rocky vs. the outer gaseous planets.
d) The processes that formed Earth's oceans and atmosphere.
e) all of the above.

26. The leading theory for the origin of Earth's Moon is
- gravitational capture of a large planetesimal.
 - fission due to rapid rotation.
 - impact by a large planetesimal, about the size of Mars, which spun off the Moon.
 - formation in the same manner as Earth, by accretion.
 - condensation from the Solar nebula.
27. The Earth's oceans and atmosphere are considered to be secondary in origin. This means that
- they formed directly by condensation from the Solar nebula.
 - they formed by outgassing of the Earth's interior.
 - they formed by reaction between an earlier atmosphere and crustal rocks.
 - they formed by the interaction of living things with their environment.
 - all of the above.
28. Free oxygen in the Earth's atmosphere has been produced mainly by
- photodissociation of water and loss of hydrogen to outer space.
 - change in sea level.
 - formation of the Earth's core.
 - photosynthesis and burial of organic carbon.
 - nucleosynthesis in stars.
29. A "runaway greenhouse" refers to
- what happened on Mars.
 - what happened on Venus.
 - a process involving a positive feedback between the amount of carbon dioxide in a planetary atmosphere and the temperature of that atmosphere.
 - both b) and c)
 - all of the above.
30. Which of the following statements is/are true?
- On Earth, H_2O is in the oceans, CO_2 is in rocks, and N_2 and O_2 are in the atmosphere.
 - On Venus, H_2O was lost to outer space as H_2 , CO_2 and N_2 are in the atmosphere, and O_2 was never present.
 - On Mars, H_2O and CO_2 are frozen out as ice, N_2 was lost to space, and O_2 was never present.
 - On Venus the atmosphere is very thick whereas on Mars it is very thin. Both atmospheres are mainly CO_2 .
 - All of the above.
31. Sea level can change as a result of
- change in the rate of seafloor spreading, which produces a change in the volume of the ocean basins.
 - change in the volume of ice stored on land.
 - local, tectonically induced vertical motions of the crust.
 - change in the temperature of ocean water.
 - all of the above.

32. A record of Earth's history going back nearly 4 billion years can be found
a) in deep-sea sediments b) in the ocean basins c) on the continents
d) in subduction zones e) all of the above.
33. From a structural standpoint, the continents consist of
a) lithosphere and asthenosphere b) cratons and mobile belts
c) volcanic arcs and subduction zones d) andesite and basalt
e) all of the above.
34. 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
a) weathering of silicate rocks by rain water and removal of CO_2 from the atmosphere into rocks.
b) photosynthesis followed by burial of some of the organic material produced.
c) the reaction by which the Earth's core formed.
d) The reaction that generates energy within the Sun and similar stars.
e) the formation of evaporite deposits that can form salt domes and trap oil and gas.
35. The simplified reaction $\text{CO}_2 + \text{H}_2\text{O} = \text{CH}_2\text{O} + \text{O}_2$ represents:
a) photodissociation b) chemical weathering c) photosynthesis
d) none of the above e) all of the above.
36. Earth, from the center outward, is composed of the following concentric layers:
a) inner core, outer core, mantle, crust
b) inner core, outer core, mesosphere, lithosphere
c) core, mantle, asthenosphere, crust
d) core, mantle, continental crust, oceanic crust
e) 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. Earth's magnetic field originates from convection currents within
a) the mantle b) the liquid outer core c) the liquid inner core d) the solid inner core
e) the asthenosphere.

39. The principle 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.
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. The Earth would probably have no continents if it did not have
- a) life
 - b) an atmosphere
 - c) oceans and subduction
 - d) both a and b
 - e) all of the above
42. Continents are built by
- a) andesitic volcanism at subduction zones.
 - b) basaltic volcanism at mid-ocean ridges.
 - c) accretion of exotic terranes onto their margins.
 - d) outgassing of volatiles from the Earth's interior.
 - e) both a and c.
43. Continental margins in the Atlantic Ocean and their offshore regions are typically described in the following order:
- a) shelf, slope, marginal basin, trench.
 - b) shelf, slope, marginal basin, volcanic island arc, trench.
 - c) shelf, slope, rise, trench.
 - d) shelf, slope, rise, abyssal plain.
 - e) shelf, slope, rise, volcanic island arc.

44. 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.
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. 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.
47. 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.
48. 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.
49. The theory of plate tectonics
- is a unifying theory for the Earth sciences.
 - holds that the Earth's surface consists of a dozen or so rigid plates.
 - holds that most mountain-building occurs along plate boundaries.
 - holds that the lithospheric plates ride on the asthenosphere.
 - all of the above.

50. The three major types of plate boundaries are
- conservative, transform, slipslide.
 - continental-continental, oceanic-oceanic, continental-oceanic.
 - divergent, convergent, conservative.
 - constructive, destructive, conservative.
 - both c) and d).
51. Which of the following terms consistently describe one type of plate boundary?
- convergent, constructive, mid-ocean ridge.
 - divergent, constructive, subduction zone.
 - divergent, conservative, transform fault.
 - convergent, conservative, mid-ocean ridge.
 - convergent, destructive, subduction zone.
52. Which of the following is a “rule” of plate tectonics?
- Oceanic crust is too thick and buoyant to be subducted.
 - The volcanic arc always forms on the upper surface of the subducting plate.
 - When continents collide with one another they tend to “stick”.
 - The major process driving the plates is convection in the Earth’s outer core.
 - All of the above.
53. Continent-continent collisions
- result when the ocean basin between them is consumed by subduction.
 - cause the crust to thicken locally, as continental crust is too thick and buoyant to subduct.
 - cause the subducting lithospheric slab to break off, after which it continues to descend on its own.
 - can cause a reorganization of plate motions.
 - all of the above.
54. Atlantic-type continental margins are considered to be aseismic, or passive, because
- they lack earthquakes.
 - they lie along a plate boundary.
 - they lie far from a plate boundary.
 - both a) and c).
 - none of the above.
55. Which of the following is an example of an active subduction zone?
- Mid-Atlantic Ridge.
 - East Pacific Rise.
 - San Andreas Fault.
 - Tibetan Plateau and Himalayan Mountains.
 - Peru-Chile Trench and the Andes Mountains.

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. 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.
58. The best place to look for petroleum in the seabed is
- a) in shallow seas floored by continental crust.
 - b) in deep-sea trenches
 - c) along continental margins
 - d) in abyssal plains
 - e) both a and c
59. 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.
60. 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.

PART 3: Short-Answer Essay Questions (total of 15 points).

Answer the following three questions entirely within the space provided. Think your answer through before starting to write. Write legibly--print if your handwriting is poor, because if the grader can't read it, it will be marked wrong.

61. (8 points) Draw a cross section of a subduction zone with an oceanic-continental boundary. Include the following features in your diagram:

a) Wadati-Benioff Zone b) trench c) oceanic and continental crust d) volcanoes e) lithosphere and asthenosphere f) direction of plate motions.

62. (7 points) a) Where and how does oceanic crust form?

b) Where and how does continental crust form? Be as specific as you can.

Answer:

a) Oceanic crust forms along mid-ocean ridges, which are divergent, constructional plate boundaries and axes of seafloor spreading. As the plates are pulled apart, *dry* asthenospheric mantle rises to fill the gap between them. A small fraction (~10%) of this upwelling mantle melts due to the decrease in pressure. This melt forms under dry conditions and is *basaltic* in composition. It separates and rises even faster, reaching the seafloor and forming new oceanic crust.

b) Continental crust forms in the volcanic arc of subduction zones. Here mantle melts under *wet* conditions to form *andesite*. These conditions are produced because the subducting plate carries sediment and altered oceanic crust, both of which contain water derived from the oceans, downward into the mantle. As the plate heats up this water is driven off. It ascends into the hot mantle of the overriding plate and lowers its melting temperature. This melt rises to form the andesite of the volcanic arc, and ultimately continental crust.