

Yale Undergraduate Science Olympiad 2017

Dynamic Planet

Exam Questions

1. Do not begin the Exam until instructed to do so.
2. Fill out the information on the cover page of both the Exam Questions and Answer Sheet.
3. Answers that ask you to “explain” or “describe,” one or two sentences is enough. Full sentences are not necessary.
4. Write all answers (and work, if required) on the Answer Sheet. **DO NOT WRITE** on this Exam Questions packet.

Identify the following statements as either true (T) or false (F).

1. Continental crust tends to be older than oceanic crust.
2. Continental crust tends to be lower in silica than oceanic crust.
3. The total volume of continental crust is greater than the total volume of oceanic crust.
4. The asthenosphere consists of the mantle and lower crust.
5. The asthenosphere is composed primarily of magma.
6. Oceanic-oceanic convergent plate boundaries result in submarine orogenic belts.
7. P-waves are detectable at the point of the Earth opposite from an earthquake's epicenter.

For questions 8–11, select the best answer from below. Answers may be used once or more than once.

- a. Observation of seismograms with two sets of P-waves and S-waves
 - b. Seismic shadow zone
 - c. Seismic tomography
 - d. Wadati Benioff zone
 - e. Seismic shadow zone
8. How was the boundary between the crust and mantle identified?
 9. How was it determined that Earth has a liquid outer core?
 10. What can be used to determine the angle of the down-going slab in a subduction zone?
 11. How was the presence of the completely subducted Farallon Plate under North America determined?

For questions 12–17, select the best geological system that occurs at the type of plate boundary listed. Answers may be used once or more than once.

- a. Orogenic belt
 - b. Mid-ocean ridge
 - c. (Subaerial) rift valley
 - d. Subduction zone
 - e. Strike-slip fault
12. Continental-continental convergent
 13. Continental-continental divergent
 14. Continental-continental transform
 15. Continental-oceanic convergent
 16. Oceanic-oceanic divergent
 17. Oceanic-oceanic convergent

For questions 18–23, select the specific geological feature from the list below that is an example of the type of plate boundary listed.

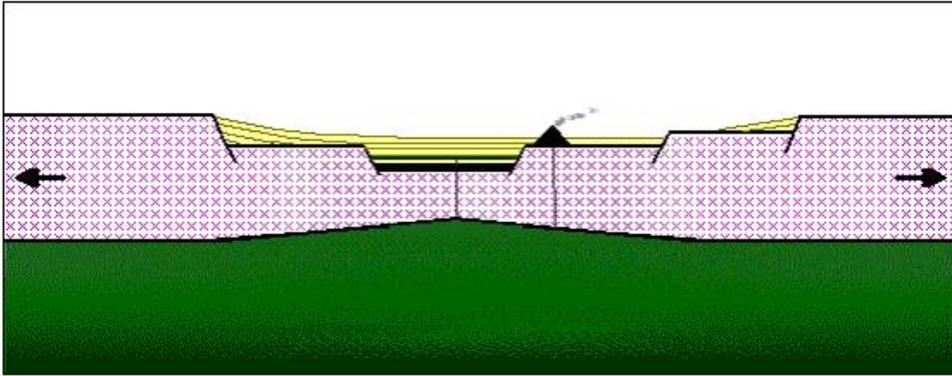
- a. East Pacific Rise
 - b. Himalaya
 - c. Japan Trench
 - d. Lake Baikal
 - e. Mariana Trench
 - f. San Andreas Fault
18. Continental-continental convergent
19. Continental-continental divergent
20. Continental-continental transform
21. Continental-oceanic convergent
22. Oceanic-oceanic divergent
23. Oceanic-oceanic convergent

For questions 24–32, select all the best answers that apply from below. There may be more than one best answer. Answers may be used once or more than once. [10 points]

- a. Lithosphere
 - b. Asthenosphere
 - c. Continental crust
 - d. Oceanic crust
 - e. Mantle
 - f. Outer core
 - g. Inner core
24. Composed primarily of iron and nickel.
25. Composed primarily of ultramafic rocks.
26. Composed primarily of mafic rocks.
27. Composed primarily of intermediate to felsic rocks.
28. Layer with the highest temperatures.
29. Flows ductilely with convection cells.
30. Responsible for the Earth's magnetic field.
31. Comprises 84% of Earth's volume.
32. Divided into tectonic plates.

33. What type of sedimentary basin is shown in the diagram below? If you need to see the diagram in color, ask your proctor.

- Back-arc basin
- Foreland basin
- Intermontane basin
- Rift basin



34. What type of sedimentary basin is shown in the map below? The basin is in the region surrounded by the oval.

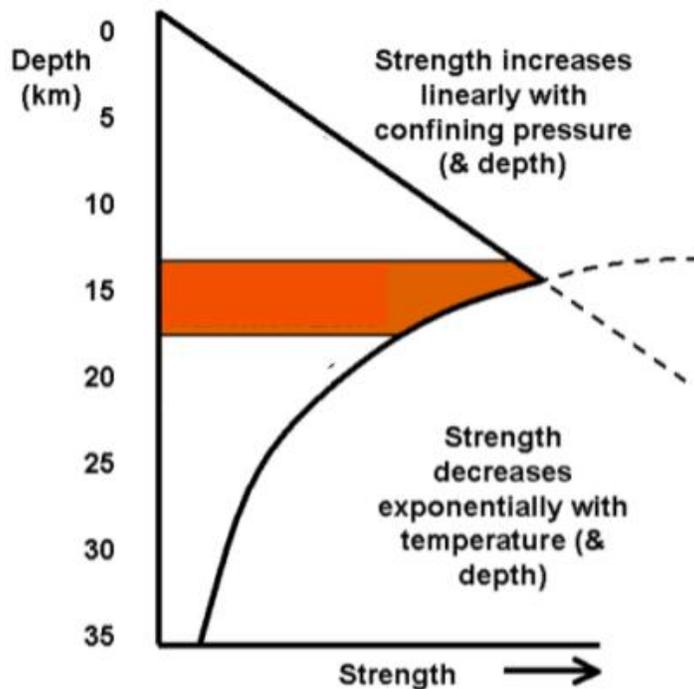
- Back-arc basin
- Foreland basin
- Intermontane basin
- Rift basin



35. Which specific geological feature is an example of an active constructive plate boundary?
- Mid-Atlantic Ridge
 - Rocky Mountains
 - Dead Sea Transform
 - Aleutian Trench
36. Which specific geological feature is an example of an active destructive plate boundary?
- Mid-Atlantic Ridge
 - Rocky Mountains
 - Dead Sea Transform
 - Aleutian Trench
37. Which specific geological feature is an example of an active conservative plate boundary?
- Mid-Atlantic Ridge
 - Rocky Mountains
 - Dead Sea Transform
 - Aleutian Trench
38. Where do the largest earthquakes occur?
- Orogenic belts
 - Mid-ocean ridges
 - (Subaerial) rift valleys
 - Subduction zones
 - Strike-slip faults
39. Which rock types are typical of most oceanic crust? Select all that apply. [2 points]
- Basalt
 - Diorite
 - Gabbro
 - Granite
 - Limestone
40. Place the following events of the formation in order from oldest to youngest. [3 points]
- Alleghanian orogeny
 - Collision of Avalonian continental fragments with Laurentia
 - Collision of volcanic island arc with Laurentia
 - Iapetus plate begins subducting under Laurentia
 - Rifting of Pangaea
41. In question 40, what is the name of the orogeny in letter B?
42. In question 40, what is the name of the orogeny in letter C?
43. Which seismologist identified the boundary between the crust and mantle in 1909?
44. Which geologist developed radiometric dating of minerals and proposed mantle convection as a mechanism for continental drift?
45. Which Princeton University geologist originated the idea of seafloor spreading?
46. What is the term for an inclusion in igneous rock that provides evidence for mantle composition?
47. What type of melting occurs at mid-ocean ridges due to a decrease in overlying pressure?
48. What type of melting occurs in subduction zones due to addition of volatiles such as water?

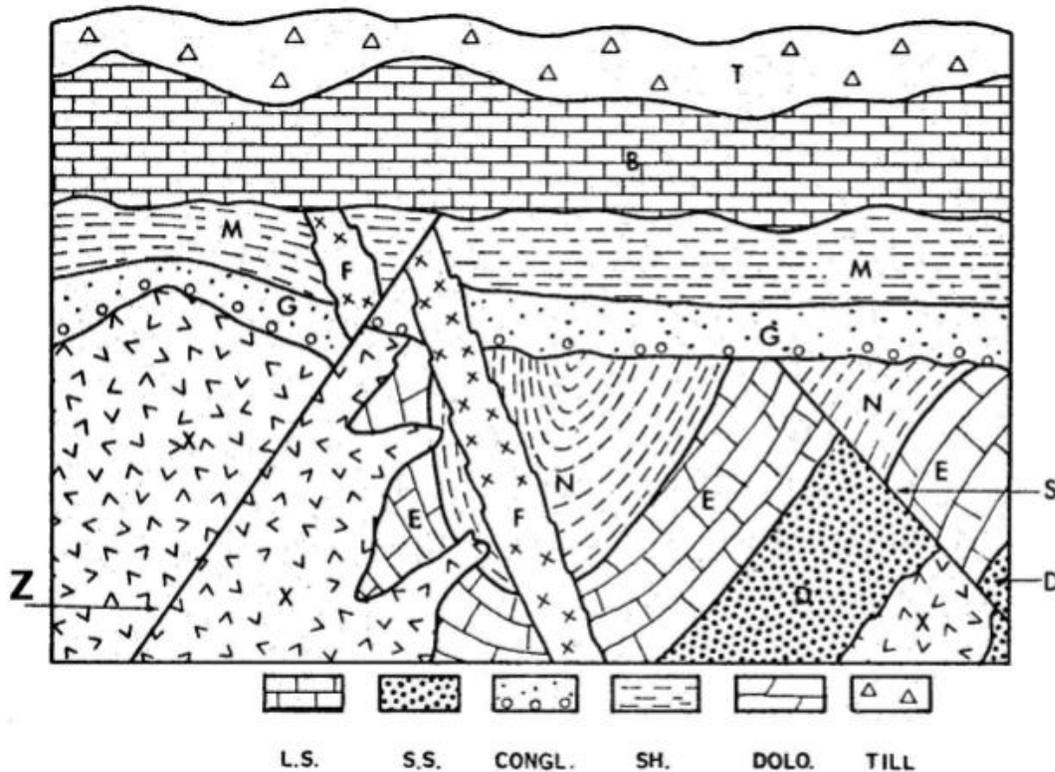
49. List two *notable* examples of hotspots in the United States. [2 points]
50. What is the term for proposed hotspot mechanisms that originate from relatively fixed areas at the core-mantle boundary?
51. What type of sedimentary basin occurs due to lithospheric flexure adjacent to orogens?
52. What is the term for the region between a volcanic arc and an oceanic trench?
53. What is the term for the area of marine sediment that accumulates on the non-subducting plate at a convergent plate boundary?
54. What is the process by which magmas residing underground progressively remove and segregate minerals as it cools?
55. In the above process, does the resulting magma become more felsic or mafic?
56. What phenomenon often occurs on reclaimed land during earthquakes and results in soil losing stiffness and acting like quicksand?
57. What device is mounted in skyscrapers such as Taipei 101 and the Tokyo Skytree in order to reduce the amplitude of vibrations from earthquakes or wind?

Questions 58–60 concern the graph below.



58. What type of strength “increases linearly with confining pressure?”
59. What type of strength “decreases exponentially with temperature?”
60. What is name of the shaded zone (around 15 km deep), the strongest part of Earth’s crust?

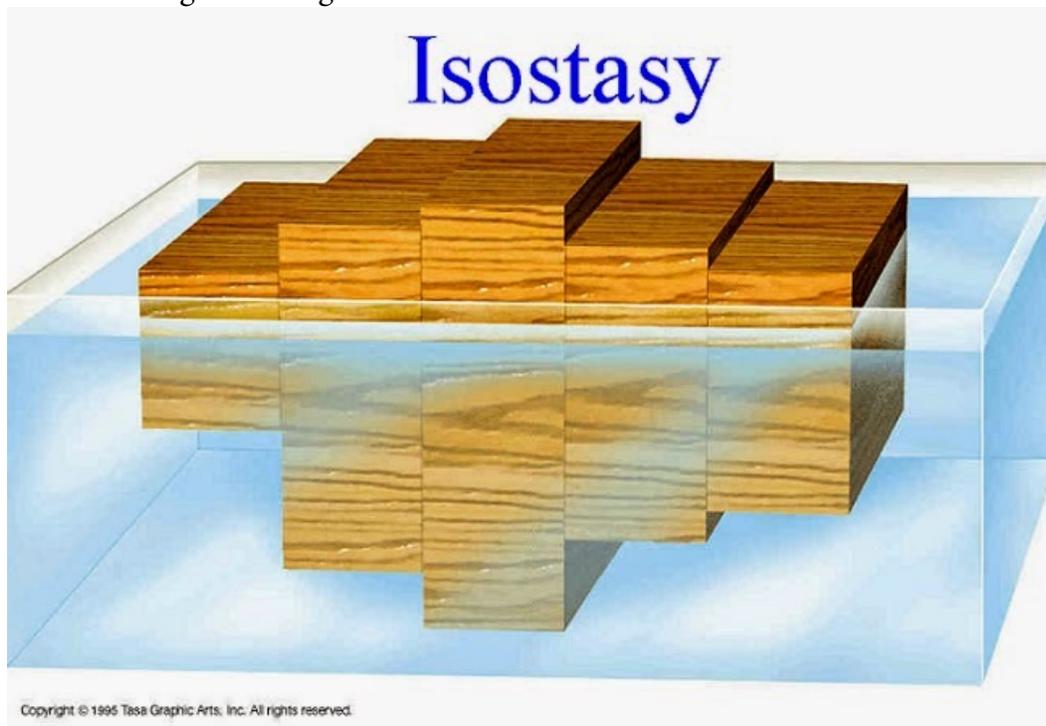
61. Who most prominently originated the theory of continental drift? List three pieces of evidence he or she used to support the theory. [4 points]
62. Explain briefly ridge push, slab pull, and trench suction. Additionally, put a star or other visible marking in your answer next to the force that is strongest. You may draw diagrams to aid your answer. [6 points]
63. Explain briefly the impact of plate tectonic activities on causing major ice ages. [2 points]
64. List the lettered events in the cross section below from oldest to youngest. [6 points]



Answer the following questions about the cross section above.

65. Assuming that layer T was deposited 10 ka, in what type of environment is the cross section most likely to be found today?
- Somewhere like Connecticut with cold winters
 - Shallow reef
 - Deep ocean
 - Rainforest
66. What does the sequence of layers D, E, and N indicate about the changes in depositional environment over time?
- Marine regression
 - Marine transgression
 - Evaporating sea
 - Periodic volcanic eruptions
67. Are the presence of faults S and Z more indicative of compressional or extensional stress?

Questions 68–69 use the (not entirely accurate) data below. Assume a simple situation in which plates float on the asthenosphere like blocks of wood in water (see diagram below for reference). Your answers will require calculations from the data. Show your work. Label units. You do not need to use significant figures.



Average Density of Continental Lithosphere	2.7 g/cm ³
Average Density of Oceanic Lithosphere	2.9 g/cm ³
Average Density of Mantle	3.3 g/cm ³
Average Thickness of Continental Lithosphere	200 km
Average Thickness of Oceanic Lithosphere	100 km

68. What thickness of oceanic lithosphere is “submerged” in the asthenosphere, to the nearest kilometer? [3 points]
69. How much does the elevation of the top of the continental lithosphere decrease if 2 kilometers of sediment is eroded away, to the 100 meters? [7 points]
70. The locations of modern-day cities Halifax (in Canada) and Casablanca (in Morocco) were roughly adjacent 220 Ma. Given that the distance between the two cities is roughly 4900 km now, what is the average rate of widening of the Atlantic Ocean over the past 220 Ma in cm/year? What is the average speed of motion of the North American plate over the same period of time in cm/year? Show your work. Label units. Use significant figures. [4 points]