

How to Build a Habitable Planet

An incomplete and partial list of review questions

1. What is steady-state disequilibrium? Give two examples from the earth or stars.
 - 1a. What are the characteristics of systems and how does “systems thinking” differ from reductionist thinking?
2. Give three examples of geological cycles in the earth.
3. Draw the appropriate diagram to illustrate what the "band of stability" is for atomic nuclei. What happens to nuclei that do not lie within this band?
4. What are the different methods used to estimate the distances of stars and galaxies from the earth? Sketch a diagram showing how the distances of some of the nearest stars can be determined.
5. The idea that the universe is finite in time and space, and that all the objects in it are fixed in their positions leads to a fundamental paradox. What is the paradox? How can it be resolved?
- 5A. What are dark energy and dark matter what is the evidence for their existence/ What fraction of the universe do they make up?
6. Sound travels at one thousand feet per second. If an ambulance is coming towards you at 500 feet per second, will you hear a higher or lower frequency than the ambulance is emitting? What is the frequency that you will hear?
7. In the red shift, what is it that is shifted?
8. Given a list of the elements in order of increasing atomic number, indicate which elements are most abundant in the earth, and why.
- 8A. Black body radiation was used in two different contexts in this course. What were those contexts and why was black body radiation an important aspect of each of them?
9. Explain why there is such a temperature contrast between the temperatures required for nuclear fusion and those required for normal chemical reactions. Would you expect that the temperature required for the fusion of two helium atoms, each of which has two protons, would be higher or lower than that required for the fusion of two hydrogen atoms, each of which has one proton? Why?
10. How are radioactive elements used to date geological materials?

11. ^{26}Al decays to ^{26}Mg with a half life of about 750,000 years. If the $^{26}\text{Mg}/^{24}\text{Mg}$ ratio is .25 at some time, call it T_0 , what else do you need to know to calculate the $^{26}\text{Mg}/^{24}\text{Mg}$ ratio 1.5 million years later? Would you expect the ratio to change significantly in the mineral olivine?
12. What is the evidence that all the bodies in the solar system formed from the same cloud of dust over a short period of time?
13. Contrast events during the big bang with events during the formation of the solar system.
14. What is the age of igneous activity on the moon? Why is this important for helping to understand the evolution of the earth?
15. How did the earth's core probably form?
16. Which elements formed during the big bang? Why didn't heavier elements form?
- 16A. What is a mineral? What is an organic molecule?
17. Given a chart of the nuclides, circle several nuclides created exclusively by the s-process, and others created exclusively by the r-process.
18. What are the s-process and the r-process? Where do they occur in the universe, and what is their result?
19. Why do geologists think that impacts played an important role in earth history, even though there is very little current evidence for them on the earth's surface?
20. What is the role of density in controlling earth structure? Include as many layers of the earth as you can.
21. What are the principal compositional differences between the inner and outer planets? Why?
22. What is the age of the solar system? How has it been determined?
24. What were the major heat sources that may have been important to the early earth history? Are any of them still important now?
25. Why are phase diagrams necessary for an understanding of how the earth evolved?
26. Sketch a phase diagram and explain what principles it illustrates that are important for the formation of the earth's major layers.

27. What is the fundamental building block of minerals? This building block combines together in different structures. Describe the structures
28. What are the major constraints on which atoms are able to combine to form minerals? Why are minerals always symmetrical?
29. Describe the various layers of Earth and the processes by which they formed.
30. What is the evidence that impacts played an important role in Earth history? What is their potential importance today?
31. Name four different kinds of meteorites and explain what they tell us about solar system and planetary formation.
32. What is about the Earth's moon that distinguished it from common moons in our solar system?
33. What are the hypotheses for the formation of Earth's moon? Which two are not currently in favor? Why?
34. Where are the Kuiper Belt and Oort Cloud located, and what is their significance?
- 29 Describe the plate tectonic geochemical cycle:
(A) Draw the cycle;
(B) State what igneous and metamorphic processes occur at the various plate boundaries, and why.
- 29A. How has Earth's climate remained stable over close to 4 billion years? Why is this surprising?
30. There are three different types of plate margins. Explain each; use diagrams to illustrate your answer.
- 30A. There were at least ten different lines of evidence for plate tectonics presented in this course. Can you name eight of them and explain why they provide evidence?
31. What is the shape of volcanoes at ocean ridges? Why does this shape differ from the classical volcanoes observed on land?
32. Ocean ridges vary in their depth from sea level at the island of Iceland to 5000 meters below sea level. What is a possible explanation?
33. Explain the processes that give rise to volcanism at convergent margins, and what may influence the extent of melting of the mantle that occurs there.

34. How well do we understand how continents form? Is there a problem in forming them with the most obvious volcanism associated with plate tectonics?
35. What type of rock is generated by partial melting of the mantle?
36. Why is amphibole such an important mineral in the plate tectonic geochemical cycle?
37. Why are convergent margin volcanos much more likely to be explosive than ocean ridge volcanos? Explain.
39. Is radioactivity necessary for the functioning of the earth? What role does it play? What are some of the most important radioactive elements?
40. What is differential volatility, and why is it important to the formation of the solar system?
41. How are lithophile, siderophile and atmophile elements distributed in the earth? How did this come about?
42. What role does oxidation state play in affecting a planet's structure?
43. How did the major layers of the earth separate from one another?
44. What are "magnetic anomalies?" How are they formed and why are they important?
45. What is the general pattern of convection in the Earth?
- 45A. What is the Rayleigh Number and what important terms are in the numerator and denominator?
46. Do volcanos have anything to do with the composition of the oceans? What?
47. What are the major heat sources available to the early earth. Is there any possibility that the early earth was mostly molten? What is the evidence?
49. Describe the different sorts of volcanic eruptions that are likely to take place at ocean ridges, hot spots, and convergent margins. Which of these volcanos would you be likely to survive visiting during an eruption? Why?
50. What are the major volcanic arcs that are part of the United States?
51. What is the significance of hydrothermal vents to the functioning and history of Earth?

53. Describe the overall evolution of the moon, and explain why the most popular model for the moon includes massive melting of the lunar interior.
54. Name the most important minerals in the different layers of the earth.
55. What is a transform fault?
56. What are hot spots and what is the evidence that they are fixed in the mantle?
57. What is the “planetary fuel cell” and what is its significance?
58. Describe two examples of continental collision and the consequences of such collisions.
59. When in Earth's history did life begin, and how do we know?
60. What are some of the major steps and hurdles that need to be understood to understand the origin of life?
61. What are the major groups of molecules in life, and what is the role of each in organic processes?
62. What are Milankovitch cycles?
63. What are possible modes of CO₂ sequestration?
64. Do the northern and southern hemisphere respond synchronously to long and short term climate change? Explain.
65. What is the significance of banded iron formations to our understanding of Earth history?
66. Describe the evolution of the atmosphere over Earth history, and what controls there have been on atmospheric composition.
67. Explain how evolution of the atmosphere and evolution of life appear to have been linked.
68. When did water first appear on the earth in liquid form, and how do we know?
69. Negative feedbacks play a vital role in the functioning of Earth. Give several examples of negative feedbacks for the Earth system, and how they lead to stability.
70. What are the four “energy revolutions” discussed in the text, and over what time intervals did each of them occur?

Charles Langmuir 3/14/02 1:01 PM

Deleted:

71. Oxygen isotopes, carbon isotopes and sulfur isotopes were all used to provide critical evidence for Earth processes. How were each of them used, and what did they reveal?
72. What are red beds and when do they occur in Earth history?
73. Describe the different classes of resources that make up Earth's treasure chest, and the time scales on which each are renewed.
74. How have planets around other stars been discovered?
75. What is the evidence that rising CO₂ in the atmosphere is caused by burning of fossil fuels?
76. What was Earth's population in the year 1600, roughly?
77. What is the Drake equation and what is its significance?
78. If there are other civilizations in our galaxy, are they likely to be more or less advanced than our own? Why?
79. What is the evidence for evolution?
80. Given a picture of strata, what rocks are the oldest and what rocks are the youngest?
81. What is used to demarcate the major stratigraphic boundaries in Earth's time scale?
82. List some of the major catastrophes that have happened in Earth's history, what their consequences were, and when they occurred.
83. How might prokaryotes and Eukaryotes be related?
84. What is the significance of the following for this course? Rayleigh number, alpha particles, short-lived radionuclides, isochrons, zircons, magnetic anomalies, hot spots, ocean ridges, hydrothermal vents, carbon sequestration, the carbon cycle, weathering, DNA, etc.