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Chapter 1 - Understanding Earth: A Dyanmic and Evolving Planet 121

CHAPTER 1 - TEST QUESTIONS

TRUE OR FALSE

1. The earth is dynamic, constantly changing in response to interactions between its interior and surface processes.

ANSWER: true

2. The study of geology is not related to such contemporary issues as acid rain because it deals with timescales of millions and billions of years.

ANSWER: false

3. The study of geology includes many other disciplines in the natural sciences, including physics, chemistry, biology, and astronomy.

ANSWER: true

4. The role of the professional geologist and the need for expertise in the area of geology is increasing because of society's focus on environmental problems and issues.

ANSWER: true

5. Metamorphic rocks are formed by the melting and crystallization of magma far beneath the surface.

ANSWER: false

6. Rocks belonging to the sedimentary group always consist of rock and/or mineral particles from pre-existing rocks.

ANSWER: false

7. Sedimentary rocks may consist of particles of pre-existing sedimentary rocks.

ANSWER: true

8. Volcanic eruptions are the source of all igneous rocks.

ANSWER: false

9. Intrusive igneous rocks form at the surface.

ANSWER: false

10. The principle of uniformitarianism includes events which are sudden and catastrophic within the realm of human perception.

ANSWER: true

11. The principle of uniformitarianism includes only processes which occur gradually.

ANSWER: false

12. The principle of uniformitarianism does not include unusual or atypical geologic events such as an ice age or asteroid impact.

ANSWER: false

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- 13. The principle of uniformitarianism includes phenomena of widely varying rates, scopes, frequencies, intensities and durations.

ANSWER: true

14. Movement along plate boundaries results in earthquake and volcanic activity.

ANSWER: true

15. Sedimentary rocks form from sediments subjected to extremely high temperatures and pressures.

ANSWER: false

16. Once rocks form they remain unchanged unless they are metamorphosed into metamorphic rocks.

ANSWER: false

17. Igneous rocks can form under many different conditions, but they are always the result of cooling and crystallization from magma.

ANSWER: true

18. Continental crust is thicker and less dense than oceanic crust.

ANSWER: true

19. If a theory stands the test of time, it becomes a fact.

ANSWER: false

20. Earth is a dynamic planet and as a result is always changing.

ANSWER: true

21. The Kyoto Protocol requires all countries to reduce their greenhouse-causing emissions proportionately.

ANSWER: false

22. Reductions of greenhouse-causing emissions by member countries according to the Kyoto Protocol is based in part on the amount of emissions being produced in 1990.

ANSWER: true

23. Solar nebula theory explains the low mean densities of the Jovian planets and high mean densities of terrestrial planets.

ANSWER: true

24. Solar nebula theory explains the large relative volume of rocky material and small relative volume of ice and gases in the terrestrial planets, and the converse in the Jovian planets.

ANSWER: true

25. All Jovian planets consist of a small rocky core surrounded by thick layers of frozen, liquid and gaseous materials.

ANSWER: true

26. Earth accreted as molten material and its layers differentiated as it cooled.

ANSWER: false

MULTIPLE CHOICE

- 27. Which of the following is a renewable resource?
 - A. natural gas
 - B. gravel
 - C. wood

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- D. uranium
- E. coal
- 28. The Earth system is composed of
 - A. the hydrosphere, lithosphere, mantle, core, biosphere, and atmosphere
 - B. a series of inputs and outputs that do not vary over time
 - C. igneous, sedimentary, and metamorphic rocks
 - D. none of the above
- 29. Which of the following best summarizes Earth?
 - A. a simple system composed of 4 subsystems
 - B. a complex dynamic planet that has changed continuously since its origin
 - C. a complex planet composed of the lithosphere, hydrosphere, and biosphere
 - D. a dynamic system of inputs and outputs
- 30. Which of these environmental problems would a geologist be most likely to address? A. the cause of acid rain
 - B. the effect of oil and gas production on atmospheric pollution
 - C. the impact of human activity on global warming
 - D. the toxicology of pesticides
- 31. Global warming is caused by
 - A. the heat generated by the burning of fossil fuels
 - B. the heat produced by sunlight and retained by carbon dioxide and other gases
 - C. increased heat produced through the hole in the ozone
 - D. increased solar radiation as the earth moves nearer the sun
 - E. none of the above
- 32. If global warming is occurring, it could potentially impact
 - A. just the atmosphere
 - B. the atmosphere and hydrosphere
 - C. the atmosphere, hydrosphere, and biosphere
 - D. the atmosphere, hydrosphere, biosphere, and the lithosphere
- 33. Earth is considered dynamic because
- A. surface landscapes are constantly changing due to erosion and deposition
 - B. the lithosphere and asthenosphere are constantly changing
 - C. rocks are susceptible to weathering
 - D. the impact of human activity is continuous
- 34. The crust, the outermost layer of Earth, consists of
- * A. continental and oceanic types
 - B. sediments and sedimentary rocks
 - C. igneous rocks originally produced by volcanism
 - D. mountains, plains, and valleys

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- 35. Theories in geology are developed through a process known as
 - A. plate tectonics
 - B. uniformitarianism
 - C. scientific method
 - D. systems approach
 - E. none of the above
- 36. According to plate tectonic theory
 - A. crust is formed along divergent boundaries and consumed along convergent boundaries
 - B. continents have drifted from their original positions
 - C. magma in magma chambers helps break continents up and push them apart
 - D. volcanism and earthquakes reflect Earth's unrest
- 37. The rock cycle is an illustration of three different rock types and
 - A. their environments of formation
 - B. their potential change over time
 - C. their relation to internal and external earth processes
- * D. A, B, and C
- 38. A transform boundary is characterized by
 - A. lithospheric plates sliding past each other
 - B. the movement of one plate over another
 - C. the movement of plates away from each other
 - D. earthquakes, but no plate movement
- 39. Plate tectonic theory is considered a unifying theory because it
 - A. explains evidence for a dynamic Earth from a variety of subdisciplines in geology
 - B. a common belief of a broad spectrum of geologists from different disciplines
 - C. current explanation for the such earth processes as volcanism and earthquakes
 - D. is the only theory explaining earth dynamics that hasn't been disproven
- 40. The three main rock types are distinguished on the basis of which of the following characteristics? A. composition
 - B. texture
 - C. size and shape of mineral or rock grains
 - D. A and B
- * E. A, B, and C
- 41. Which of the following best describes sedimentary rocks?
 - A. deposition of ash and larger particles produced by volcanism
 - B. weathering, transport, and deposition of sediment from pre-existing rocks
- * C. compaction and cementation of rock fragments, precipitates, and organic matter D. alteration of sediment by heat, pressure, and the chemical activity of water
- 42. The evidence supporting the "Big Bang" theory includes
 - A. an expanding universe
 - B. a pervasive background radiation everywhere in the universe
 - C. the existence of the Doppler effect
- * D. A and B
 - E. all of the above
- 43. Mercury, Venus, Earth, and Mars are similar in that they have similar
 - A. tectonism
 - B. volcanism
 - C. composition
 - D. internal temperatures
 - E. all of the above

FILL-IN

44. ______ are accreting masses of gases, liquids, and solids which eventually become true planets?

ANSWER: planetesimals

- 45. Among earth's natural resources, _____ and _____ are used in your home or were used to construct your home.
- ANSWER: Gypsum in wallboard, calcite/limestone in concrete, quartz in glass windows, electrical wiring, and the water and energy provided to your home.
- 46. With regard to Earth's interior, the is ______ solid, the ______ is liquid
- ANSWER: inner core, outer core

47. The lithosphere is comprised of the _____ and the upper part of the _____.

- ANSWER: crust, mantle
- 48. The three types of tectonic plate boundaries are _____, ____, and _____.
- ANSWER: divergent, convergent, and transform
- 49. Subduction is associated with _____ plate boundaries
- ANSWER: convergent
- 50. The discovery of _____, near the turn of the century, led to the development of techniques for determining absolute ages of rocks in years.
- ANSWER: radioactivity
- 51. The basic premise of the principle of ______ is that present-day processes have operated throughout geologic time.

ANSWER: uniformitarianism.

MATCHING

- 52. Match the following topics of study in geology.
 - _____ minerals
 - _____ evolution of life
 - _____ stream processes
 - _____ changes in stream processes over time
 - _____ early Earth's atmosphere
 - Earth's interior

ANSWER: B, A, B, A, A, B

A. historical geology B. physical geology

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53. Match the natural resource with its correct use in or around the home.

energy	A. Copper
concrete	B. Limestone/Calcite
windows	C. Coal
wall board	D. Quartz
wiring	E. Gypsum

ANSWER: C, B, D, E, A

54. Match the earth phenomena with the plate boundary type(s). Include as many plate boundaries as are appropriate.

volcanism	A. convergent
earthquakes	B. divergent
subduction	C. transform
wiftin a	

_____ rifting

ANSWER: A/B/C, A/B/C, A, B

55. Match the following characteristics with the appropriate rock type.

- _____ transportation of rock grains
- A. igneous B. sedimentary
- _____ mineral crystallization
- C. metamorphic
- _____ high pressure interlocking mineral grains
- _____ precipitation from solution
- foliated texture

ANSWER: B, A, C, A/C, B, C

56. Match the geologic specialty with the area of study.

Geophysics	A. Earth's interior
Seismology	B. rock deformation
Paleontology	C. landforms
Geomorphology	D. fossils
Structural Geology	E. Rocks
Petrology	F. earthquakes

ANSWER: A, F, D, C, B, E

CRITICAL THINKING

- 57. How is the rock cycle related to plate tectonics?
- ANSWER: Plate tectonics creates the conditions or environment in which the different rock types are formed. An apppropriate answer would include examples for each rock type relative to a plate boundary or process along a boundary.
- 58. Select two of Earth's subsystems and describe how they interact with each other.
- ANSWER: The answers here will probably reflect discussions in the book or from class, but encourage students to focus on real interactions, where change in one subsystem leads to or dependent on change in another. For example, lithospheric processes such as mountain building impact weather patterns and the amount of rainfall. This in turn affects soils and stream systems.
- 59. Using one of the theories presented in the chapter, describe the observations that geologists used to support the theory.
- ANSWER: Plate tectonic theory will probably be chosen by many. The observations that support it may vary from spatial distribution of earthquakes and volcanoes to the subdivisions of the earth.

- 60. Is plate tectonics a fact or a theory? Explain.
- ANSWER: An appropriate answer here might begin with definitions of fact and theory. Given that a theory is a coherent explanation for one or several related natural phenomena that is supported by a large body of objective evidence, the answer may illustrate this using several phenomena supporting plate tectonic theory.
- 61. Use an example to illustrate why the study of geology might involve more than one of Earth's subsystems.
- ANSWER: Because of the interactions between the different subsystems, geologists can rarely isolate a single subsystem. Look for illustrations that get to specific impacts or dependencies of one subsystem on another.

SHORT ANSWER

- 62. What is meant by the term "system" as it is used in discussing Earth's complexity?
- ANSWER: It is a combination of related parts that interact in an organized fashion.
- 63. How is Earth unique among the planets of our solar system?
- ANSWER: Earth supports life, has oceans of water, has a hospitable atmosphere, has a variety of climates.
- 64. In addition to a hospitable atmosphere and climates, what are other favorable conditions for life's existence on Earth that we know?
- ANSWER: the presence of water, low levels of carbon dioxide
- 65. What are the two broad areas into which the field of geology is divided?
- ANSWER: historical geology and physical geology
- 66. Give two examples of geology-related environmental concerns and briefly explain why geology holds the focal position of environmental science?
- ANSWER: water quality and distribution, soil formation and erosion. Geology concerns all aspects of the physical Earth and their interactions with the biosphere.
- 67. What is one way in which geologic knowledge is used to help humans?

ANSWER: finding mineral or energy resources/helping solve environmental problems/predicting natural hazards

- 68. How have geologic natural resources been important in history?
- ANSWER: States, nations, empires have risen and fallen because of, and fought for control of, natural resources.
- 69. How has geology been important to the arts and literature?
- ANSWER: It has inspired artists, especially landscape artists, musicians, and writers for centuries.
- 70. Give one specific example of how geology has an effect on your daily life in terms of materials and energy needs.
- ANSWER: Coal is used in producing steel and other materials, and supplies an increasing percentage of our energy needs.

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- 71. Give one example of how you might use geology as you prepare to purchase property on which to build your home.

ANSWER: Two of the most common natural hazards that affect homeowners are landslides and floods.

- 72. How does knowledge of geology benefit other professions? Provide one example.
- ANSWER: Property rights to natural resources and environmental assessments are becoming important for lawyers. Politicians are increasingly faced with legislation and issues related to the physical environment.
- 73. What was the origin of the material which now forms the solar system, according to a current theory?

ANSWER: Interstellar material in a spiral arm of the Milky Way Galaxy, which condensed and collapsed.

- 74. By how long ago had the early Earth formed?
- ANSWER: 4.6 billion years ago

75. On what bases are the concentric layers of Earth primarily distinguished?

ANSWER: variations in pressure, temperature and composition

76. Why is Earth considered to be a dynamic (as opposed to static) planet?

ANSWER: Earth has been continuously changed through its 4.6 billion year existence.

77. What are the two types of crust?

ANSWER: oceanic, continental

78. Which of Earth's major concentric divisions forms the largest volume?

- ANSWER: the mantle
- 79. The lithosphere is comprised of which layer or layers?
- ANSWER: the crust and the underlying upper mantle
- 80. What are the three zones into which the mantle can be divided, based on physical characteristics?

ANSWER: solid inner mantle, plastic asthenosphere, solid upper mantle

- 81. Given that the asthenosphere behaves like a plastic, deforming under high pressures and temperatures, explain why oceanic crust always occurs at lower elevations/greater depths than continental crust.
- ANSWER: Oceanic crust is denser than continental crust and both "float" at equilibrium levels on the deformable asthenosphere.
- 82. Give a definition for the term "theory" as it is used in science.
- ANSWER: a coherent explanation for one or several related natural phenomena that is supported by a large body of objective evidence
- 83. Briefly explain the differences between hypothesis and theory.
- ANSWER: A theory is a systematic, broad-scope explanation consisting of one or more hypotheses that have been or can be tested and that provide predictions that permit verification or rejection. A hypothesis is an untested explanation of incomplete scope, from which there may or may not emerge verifiable predictions.

- 84. What fact about scientific theories best distinguishes science from other forms of human inquiry?
- ANSWER: Scientific theories are always subject to further testing, which may result in their being supported or rejected.
- 85. Briefly explain how human conflicts over mineral resources and territory could ultimately be considered the result of the products and processes of plate tectonics.
- ANSWER: Geology, including the distribution of resources, is determined by plate tectonic motions. In turn, geology determines physical geography and the distribution of natural resources. Physical geography and resources shape the political and cultural presence of peoples, as well as their histories, and futures.
- 86. What are the three types of tectonic plate boundaries?
- ANSWER: divergent, convergent, and transform
- 87. With which type(s) of plate boundaries is subduction associated?

ANSWER: convergent boundaries

88. With which type(s) of plate boundaries is volcanic activity generally associated?

ANSWER: divergent and convergent

89. With which type(s) of plate boundaries are earthquakes associated?

ANSWER: divergent, convergent, transform (all three)

- 90. Briefly describe the meaning of the term "plate" in "plate tectonic theory."
- ANSWER: rigid independent sections of lithosphere which move about on the surface of the asthenosphere and interact along their boundaries.
- 91. Briefly describe the role of plate tectonics in geological processes:
- ANSWER: Convergence, divergence, and transform movement of plates cause faulting, folding, earthquakes, mountain building, and volcanism. Subduction results in partial recycling of crust to mantle.
- 92. Briefly describe how the discovery of sea floor spreading transformed the continental drift hypothesis into the theory of plate tectonics.
- ANSWER: Sea-floor spreading demonstrated that new crust was continually being formed and that continental and oceanic crust moved together as a unit or plate in response to the forces that cause sea-floor spreading.
- 93. Who proposed the hypothesis of continental drift, and when?

ANSWER: Alfred Wegener, 1912

94. After Wegener's hypothesis of continental drift was rejected, what laterhypothesis was proposed to explain new data obtained from studies of the ocean floors?

ANSWER: sea-floor spreading

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- 95. Briefly explain, using plate tectonics as an example and clearly stating each step, how the scientific method may be used to formulate a hypothesis and then transform it into theory.
- ANSWER: The hypothesis of continental drift was rejected and then resurrected in modified form (motion of plates) as the combined explanatory-predictive theory emerging from the hypotheses of sea floor spreading, paleomagnetic reversal, and subduction.
- 96. What is the difference between a rock and a mineral?
- ANSWER: A rock is an aggregate of minerals. Minerals are naturally occurring, inorganic, crystalline solids that have definite physical and chemical properties.
- 97. What are the three major groups of rocks?
- ANSWER: igneous, sedimentary, metamorphic
- 98. What is the sequence of steps in the formation of sedimentary rocks?
- ANSWER: weathering, erosion, transportation, deposition and consolidation/lithification
- 99. How do igneous rocks form?
- ANSWER: crystallization of magma
- 100. How do metamorphic rocks form?
- ANSWER: by alteration of other rocks, usually underground, as a result of heat, pressure, and chemical activity
- 101. Why are igneous rocks classified as either intrusive or extrusive if both originate from melted material many kilometers beneath the surface?
- ANSWER: because the property of crystalline texture differs between rock crystallized at or near the surface and rock crystallized far below the surface
- 102. Name the three transporting agents or media which produce sediment deposits and, ultimately, sedimentary rocks.
- ANSWER: water, wind, glaciers
- 103. Along which plate boundary types are metamorphic rocks formed?
- ANSWER: largely along convergent boundaries.
- 104. Along which tectonic plate boundary type(s) are igneous rocks formed?
- ANSWER: divergent and convergent
- 105. Which plate boundary type is not strongly associated with the formation of any rock family?
- ANSWER: transform boundary
- 106. Why can the rock cycle, including its surface processes, be considered part of plate tectonics? Use examples from each group of rocks in your explanation.
- ANSWER: Igneous rocks form by intrusive and extrusive processes at convergent plate boundaries, become part of the continents, and thus, further differentiate continental crust from oceanic crust. These rocks weather to form sediments and sedimentary rock, some of which is returned to the mantle and remelted, only to rise

again during sea-floor spreading. Sedimentary and igneous rocks at convergent margins are metamorphosed and eventually turned into sedimentary rocks.

- 107. Plate tectonics is a global process which has components of both surficial and internal change. Name each. Which one of the two drives the other, and which one is, in part, the product of the other?
- ANSWER: convection and partial melting (internal), the rock cycle (surficial). The internal process drives the external one. The rock cycle is a product of the internal process (especially so when it is considered that water and the atmosphere originated from volcanic outgassing).
- 108. What discovery, near the turn of the century, led to the development of techniques for determining absolute ages of rocks in years?
- ANSWER: radioactivity
- 109. What is the basic premise of the principle of uniformitarianism?
- ANSWER: Present-day processes have operated throughout geologic time.
- 110. Explain why the concept of geologic time is important to geologists.
- ANSWER: It allows geologists to show how small, almost imperceptible changes over vast lengths of time have resulted in significant changes.
- 111. How is the age of the universe estimated?
- ANSWER: by the rate at which galaxies are moving away from one another
- 112. What are the two fundamental phenomena that are taken as evidence for the Big Bang origin of the universe?
- ANSWER: The galaxies are all moving away from one another, and there is a universal background radiation slightly above absolute zero.
- 113. What are the four basic forces responsible for all interactions of matter?
- ANSWER: gravity, electromagnetic force, strong nuclear force, weak nuclear force
- 114. Briefly describe the current theory of the origin of the early universe.
- ANSWER: Scientists believe that the universe originated with the Big Bang between 13 and 20 billion years ago. In the first second following the Big Bang the four basic forces separated and the universe experienced enormous expansion. Matter and antimatter collided leaving a slight surplus of matter. Three minutes after the Big Bang, matter became cool enough for protons and neutrons to fuse to form the nuclei of helium and hydrogen atoms. Roughly 100,000 years later electrons joined these nuclei to make complete atoms while photons separated from matter to make light. Stars and galaxies formed as the universe continued to expand and cool and the chemical makeup of the universe underwent change from having been 100% hydrogen and helium to its current composition of 98% hydrogen and helium.
- 115. Name the terrestrial planets.
- ANSWER: Mercury, Venus, Earth, Mars
- 116. Name the Jovian planets.
- ANSWER: Jupiter, Saturn, Uranus, Neptune

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- 117. How do the Jovian planets differ from the terrestrial plants?
- ANSWER: The Jovian planets are large and have low mean densities, and are composed largely of gases and heavy elements.
- 118. Briefly narrate the solar nebula theory of the solar systems' origin.

ANSWER: Interstellar matter in an arm of the Milky Way Galaxy condensed and collapsed. The gravity that influenced the collapse also caused a cloud to flatten and begin to rotate. As 90% of the mass was concentrated in the central part of the cloud an embryonic sun formed, surrounded by a turbulent rotating cloud called a solar nebula. Localized eddies within the nebula formed in which gas and solid particles condensed and began to accrete into planetesimals that eventually became planets. The material that had concentrated at the center of the nebula condensed and collapsed under gravity to form a new star, the Sun.

119. What is the value of forensic geology?

ANSWER: Geologic materials can be diagnostic of specific places. A forensic geologist examines earth materials involved in crime scenes to determine where a crime was committed or where a criminal had been.