

Chapter 1 - Understanding Earth

Essay

1. What is the definition of theory as used in science? How is the word misused in day-to-day language?

ANSWER: A theory in science is a coherent explanation for one or several related natural phenomena that is supported by a large body of objective evidence. In other words, theory is used to mean an idea; the better term for that would be hypothesis. In day-to-day language it is misspoken in situations that are irrelevant to the term.

2. What distinguishes science from other forms of human inquiry?

ANSWER: Scientific ideas are based on data and observation that can be tested. Other forms of inquiry are based on faith, emotion, or something else that cannot be scientifically tested.

3. What is the scientific method?

ANSWER: The scientific method is a systematic orderly, logical approach to understanding our world that involves gathering and analyzing data about natural phenomena, formulating hypotheses to explain them, testing the hypotheses, which, if the hypothesis survives, is subsequently put forth as a theory.

4. How is a theory formulated?

ANSWER: Theories are formulated using scientific methods. Observations and data are gathered to test the problem. Tentative explanations, also called hypotheses, are then formulated to explain the observations and data. More tests are conducted and the data are analyzed. If the data show that the hypothesis is not correct, it is rejected. If the data all support the hypothesis, there are no significant data refuting it, and it is accepted by scientists, it becomes a theory.

5. How have natural resources been important in history? Provide an example of a situation in which natural resources have altered the course of history.

ANSWER: States, nations, and empires have risen and fallen, and they have fought for control of, or sometimes lost, natural resources. There are many examples one of which is colonization of parts of Africa and Asia by some European countries.

6. Describe the ways in which geology affects our everyday lives.

ANSWER: Natural disasters profoundly affect the regions and nations that they strike. Many of the resources, especially water and soil necessary for human existence are often taken for granted, and other resources, such as metal, oil, natural gas, etc. are located and made useful by geologists. Also environmental problems are often related to human activities on Earth systems.

7. What is the greenhouse effect, and how does it work? What happens when greenhouse

gas levels in the atmosphere increase?

ANSWER: Carbon dioxide and other greenhouse gases such as ozone, water vapor, nitrous oxides, chlorofluorocarbons, and methane are natural components of the atmosphere. These gases allow sunlight to pass through the atmosphere but trap some of the heat that radiates outward from Earth's surface. This is the greenhouse effect. If the amount of greenhouse gases in the atmosphere increases, they can trap more heat, and thereby raising the temperature on the Earth's surface.

8. What are some of the consequences of global warming predicted to be?

ANSWER: Warmer temperatures overall; melting glaciers that would result in the loss of freshwater, ice caps, and sea ice; increased droughts in some locations, increased precipitation in other locations; difficulty growing food in some agricultural areas; and spread of tropical diseases into areas that have been too cold.

9. What are two examples of geology-related environmental concerns? Briefly explain why geology holds an important position in environmental science.

ANSWER: Water quality and distribution, soil formation and erosion, monitoring pollution, finding suitable locations for power plants and other potentially dangerous buildings, climate change, minimizing the effects of natural disasters such as landslides, etc.—there are numerous to choose from.

10. Why is overpopulation a concern geologically?

ANSWER: Resources are unevenly distributed on Earth. Earth can support a finite number of people based on the resources, which is termed as the carrying capacity, which is the ability of Earth to support certain number of individuals without undue burden on all of its resources. Overpopulation would negatively affect the carrying capacity, which would result in straining the resources and affecting the environment. Overpopulation would also affect the environment by aggravating natural disasters (rockfalls, landslides, mudslides, etc.) and contributing increased levels of all forms of pollution.

11. Describe how the universe, galaxies, stars, and chemical elements formed.

ANSWER: Scientists believe that the universe originated with the Big Bang approximately 14 billion years ago. At the moment of the Big Bang, there was only energy and matter was absent. In the first second following the Big Bang, the four basic forces separated, and the universe experienced enormous expansion. Galaxies and stars came together, and the chemical makeup of the universe changed. In the early universe, the only chemical elements were hydrogen and helium, but now 2% of the universe comprises of allelements (other than hydrogen and helium) by weight.

12. Briefly explain the solar nebula theory of Earth's origin, including how and why it came to be differentiated by composition.

ANSWER: In the solar nebula theory, gases and solid particles condensed in localized eddies and then accreted into planetesimals. These bodies collided and grew until they became planets. The planets nearer the Sun were small and composed of rock and metallic elements. One of these was Earth. Heat was generated by meteorite impacts,

gravitational compression, and nuclear reactions. The heat caused the material to melt. Since it could now move, dense metals sank to the core and denser silicates to the mantle. Lighter silicates rose to form the crust.

13. Briefly explain with the help of a couple of examples how Earth behaves as a dynamic planet.

ANSWER: Earth is not static. It is constantly changing in terms of severe weather conditions witnessed, volcanic eruptions, earthquakes, and weathering processes that occur, which maintains its dynamic nature.

14. Name, locate, and describe Earth's three concentric layers. What are these divisions based on and what volume does each layer take up?

ANSWER: The three concentric layers are determined by density. At Earth's center is the densest layer, the core, with a calculated density of 10–13 grams per cubic centimeter. At 16% of the total volume, the core is mostly iron with a small amount of nickel. There are two layers, a solid interior and a liquid-molten outer core. The mantle makes up most of the planet's volume, 83%. The mantle is much less dense than the core, 3.3–5.7 grams per centimeter cubed. It is composed mostly of dark, dense peridotite. The outermost layer is the least dense layer, the crust. There are two major types, continental crust, which is granitic and is thicker compared to the oceanic crust and has an average density of 2.7 grams per cubic centimeter and oceanic crust, which is granitic and is thinner compared to continental crust and density at 3.0 grams per cubic centimeter.

15. How are the rock cycle and plate tectonics related?

ANSWER: Interactions between plates, such as collisions, subductions, lateral and vertical movement, determine, to some extent, which of the three rock groups will form. Plates may melt and subsequently crystallize to form igneous rocks, be altered via heat and pressure without melting to form metamorphic rocks, or exposed by weathering, chemical, and organic to form sediments, which subsequently form sedimentary rocks. All three types of rocks are connected as well as interrelated (like a bicycle wheel with spokes connecting to the rim of the wheel).

16. Briefly explain how the themes of plate tectonics, organic evolution, and geologic time provide a cohesive story of the history of Earth.

ANSWER: Earth has evolved internally and externally. As internal processes were established, they played a role in what was happening on the surface of Earth as the atmosphere, hydrosphere, and landmasses developed. Organic evolution was directly dependent on development of favorable conditions for various life forms. The net result of the physical, chemical, and biological evolution of Earth has been profound, particularly, in view of the amount of time necessary for those changes to take place (synthesis).

17. Briefly explain how geologists can formulate theories about events that occurred on Earth before humans were here to make observations.

ANSWER: Geologists base their theories on two assumptions. First, that rocks record the

processes that were involved in formation of those rocks. Second, that uniformitarianism is true, and the present is the key to the past. This means that basic physical, chemical, and biological processes have not changed and that are operational today have been in operation in the past, and that if we study and understand them today, we can apply what we learn to conditions in the past.

18. Briefly explain the importance of the geologic time scale.

ANSWER: The geologic time scale is the result of work by many geologists worldwide who used fossils, rock records, and relative and radiometric dating techniques to determine a chronology for the evolution of Earth and existence of life through time.

19. Briefly explain the importance of the principle of uniformitarianism to the study of historical geology.

ANSWER: Uniformitarianism provides the basis for interpreting the geologic history of Earth because geologists cannot travel back in time to study events. By using modern analogies, geologists can make reasonable interpretations about past events.

20. Briefly list a few examples that would support the principle of uniformitarianism.

ANSWER: Processes occurring today such as earthquakes, volcanic eruptions, and severe weather serve as good examples regarding the principle. The principle narrates that these processes have been in occurrence even prior to human existence.

Subjective Short Answer

21. What is a system? What are four Earth systems?

ANSWER: A system is a combination of related parts that interact in an organized fashion. Earth systems include the atmosphere, biosphere, hydrosphere and geosphere.

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

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

23. What does geology have to do with the standard of living that societies have?

ANSWER: One of the many activities that geologists engage in are locating and extracting the mineral deposits and petroleum resources necessary for industrialization that results in a healthy economy, and therefore, a higher standard of living.

24. What is one way in which geologic knowledge is used to benefit humans?

ANSWER: There are several possible answers to this, including but not limited to exploring mineral, energy resources, addressing environmental problems, etc.

25. What are the characteristics of the terrestrial planets?

ANSWER: The terrestrial planets also referred to as inner planets—Mercury, Venus,

Earth, and Mars—are smaller compared to Jovian planets and are composed of rock and metallic elements that condensed at the high temperatures of the inner solar nebula.

26. What are the characteristics of the Jovian planets?

ANSWER: The Jovian planets also referred to as outer planets—Jupiter, Saturn, Uranus, and Neptune—are larger compared to terrestrial planets comprising of gaseous bodies with rings and heavy atmospheres.

27. What is Pluto now that it is no longer a planet, and what are the characteristics of that type of body?

ANSWER: Pluto is now a dwarf planet along with two other dwarf planets Ceres and Eris. These bodies are similar to planets, but they have not cleared their portion of space of debris. Pluto is found within the Kuiper Belt of comets and other icy debris.

28. Describe how temperature increases will occur in all global warming scenarios.

ANSWER: Average global temperature will rise everywhere but the greatest effect will be felt in higher latitudes (as a result of more people living in those regions and industrialization) of the Northern Hemisphere, which already being observed with the melting of ice caps and glaciers.

29. What is Doppler effect?

ANSWER: Doppler effect is an increase or the decrease in the frequency of a sound, light, or other wave caused by the movement of the wave's source closer or further away from the observer.

30. What are the three types of tectonic plate boundaries?

ANSWER: Divergent, convergent, and transform.

31. What extremely important theory is as foundational and unifying to geology as the theory of evolution is to biology?

ANSWER: Plate tectonic theory.

32. 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 crystalline structure and a definite or a range of chemical composition.

33. What are the three ways sedimentary rocks can form?

ANSWER: (1) Consolidation of mineral or rock fragments (detrital or clastic), (2) precipitation of mineral matter from solutions (chemical), or (3) compaction of plant or animal remains (organic).

34. How do igneous rocks form?

ANSWER: Magma crystallizes or accumulation and consolidation of volcanic ejecta.

35. How do metamorphic rocks form?

ANSWER: The alteration of preexisting rocks as a result of heat, pressure, and chemical activity in a solid state.

36. What is natural selection?

ANSWER: Natural selection is the mechanism that drives organic evolution. Organisms that are best adapted to their environment are more likely to survive and reproduce and pass their genetic traits on to the next generation.

37. What is the basic premise of the principle of uniformitarianism?

ANSWER: Present-day processes have operated throughout geologic time. Present is the key to the past.

38. What is the name of the method that is used to determine the absolute age of a rock body?

ANSWER: Radiometric dating.

39. Historical geology is the study of _____.

ANSWER: the origin and evolution of Earth and its continents, oceans, atmosphere, and life using principles and methods to reconstruct the geological history of Earth (also referred to as paleogeology)

40. Physical geology is the study of _____.

ANSWER: Earth materials, such as rocks and minerals, as well as the processes operating within Earth and on its surface

Completion

41. Earth formed _____ billion years ago.

ANSWER: 4.6

42. Theories are formed via a process called _____.

ANSWER: the scientific method

43. A combination of related parts that interact in an organized fashion is a(n) _____.

ANSWER: system

44. Earth's human population reached _____ in 2011 and is projected to be _____ in 2045.

ANSWER: 7 billion, 9 billion

45. Global warming is caused by increased concentrations of _____ in the atmosphere.

ANSWER: greenhouse gases

46. When the universe originated, it was composed of 100% _____ and _____, but now consists of _____% hydrogen and 2% _____ elements.

ANSWER: hydrogen, helium, 98, other

47. The scientific theory for the origin of our solar system, involving the condensation and collapse of interstellar material in a spiral arm of the Milky Way galaxy, is the _____ theory.

ANSWER: solar nebula

48. Mercury, Venus, Earth, and Mars are referred to as _____ planets.

ANSWER: terrestrial

49. Jupiter, Saturn, Uranus, and Neptune are referred to as _____ planets.

ANSWER: Jovian

50. The material in Earth's inner core is _____, while the outer core is _____.

ANSWER: solid, liquid-molten

51. The crust and the underlying uppermost mantle make up the _____.

ANSWER: lithosphere

52. The two types of crust are _____ and _____.

ANSWER: oceanic, continental

53. The solid upper mantle and the overlying crust is referred to as _____.

ANSWER: lithosphere

54. The two primary materials that geologists use as clues to understand Earth's past are

_____ and _____.

ANSWER: rocks, fossils

55. The three eras that have taken place since the end of the Precambrian from oldest to youngest are the _____, _____, and _____.

ANSWER: Paleozoic, Mesozoic, Cenozoic

56. Substances that are naturally occurring in a solid state, with a definite or a range of chemical composition and definite crystalline structure are called _____.

ANSWER: minerals

57. Assemblages of mineral(s) are generally referred to as _____.

ANSWER: rocks

58. The theory that modern-day organisms are related and happen to have descended with modifications from organisms living in the past is called the theory of _____.

ANSWER: organic evolution

59. The explanation present is the key to the past is referring to the principle of _____.

ANSWER: uniformitarianism

Multiple Choice

60. Which of the following statements about a scientific theory is not true?

- a. It is an explanation for some natural phenomena.
- b. It has a large body of supporting knowledge.
- c. It is testable.
- d. It is conjecture or guess.
- e. none of the above

ANSWER: d

61. A hypothesis is

- a. thought to be the truth by most scientists.
- b. a tentative explanation.
- c. a description of something that happens without fail.
- d. a guess.

ANSWER: b

62. Science does not utilize beliefs or supernatural explanations because they

- a. have been proven to be true and so science isn't needed.
- b. none of these.

- c. have been proven to be untrue.
- d. cannot be tested.

ANSWER: d

63. Most scientists argue that the greatest environmental problem facing the world today is:

- a. climate change.
- b. the ozone hole.
- c. water pollution.
- d. overpopulation.

ANSWER: d

64. The Big Bang took place approximately ____ years ago.

- a. 140 billion
- b. 40 billion
- c. 14 billion
- d. 14 million
- e. 14,000

ANSWER: c

65. The age of the universe is estimated by the:

- a. temperature of the universal background radiation.
- b. age of comets formed in interstellar space.
- c. rate at which galaxies are moving away from one another.
- d. age of subatomic particles as determined by radioactive decay.

ANSWER: c

66. At the moment of the Big Bang, both ____ and ____ were compressed into an infinitely small high-temperature and high-density state.

- a. matter, energy
- b. gravity, energy
- c. nuclear power, matter
- d. energy, matter
- e. matter, weak nuclear forces

ANSWER: a

67. At the moment of the Big Bang, both ____ and ____ were set at zero.

- a. matter, energy
- b. time, space
- c. nuclear power, weak nuclear forces
- d. gravity, chemistry

ANSWER: b

68. The Jovian planets are:

- a. Jupiter, Saturn, Uranus, and Neptune.
- b. Mercury, Venus, Earth, and Mars.
- c. Earth, Mars, and Jupiter.
- d. Uranus, Neptune, and Pluto.

ANSWER: a

69. The zone between the core and the crust is the:

- a. asthenosphere.
- b. lithosphere.
- c. mantle.
- d. convection center.

ANSWER: c

70. Earth's core is probably:

- a. composed of rock with high silica content.
- b. molten throughout.
- c. composed of potassium- and aluminum-rich silicates.
- d. composed mostly of iron and nickel.

ANSWER: d

71. Which of the following statements about the asthenosphere is not true?

- a. It lies beneath the lithosphere.
- b. It is a rigid rock layer.
- c. It behaves plastically.
- d. Partial melting within it generates magma.

ANSWER: b

72. The theory that all living organisms are descendants of different life forms that existed in the past is called:

- a. organic evolution.
- b. paleontology.
- c. plate tectonics.
- d. natural selection.

ANSWER: a

73. Fossils are:

- a. useful for reconstructing past environmental conditions.
- b. evidence that evolution has occurred.
- c. evidence that Earth has a long history predating humans.
- d. the remains or traces of once-living organisms.
- e. all of the above

ANSWER: e

74. In the 19th century, geologists developed the geologic time scale using

- a. fossils.
- b. radiometric dating techniques.
- c. absolute ages.
- d. the principle of uniformitarianism.

ANSWER: d

True / False

75. Historical geology is the study of how geology is related to human history.

- a. True
- b. False

ANSWER: False

76. Physical geology involves the study of Earth materials as well as processes operating on the surface and within Earth.

- a. True
- b. False

ANSWER: True

77. Scientists have indicated that there is no supernatural or spiritual realm.

- a. True
- b. False

ANSWER: False

78. A theory—such as the theory of plate tectonics or the theory of evolution—is not accepted by a large number of scientists.

- a. True
- b. False

ANSWER: False

79. Many wars are fought over natural resources.

- a. True
- b. False

ANSWER: True

80. Overpopulation will affect many Earth systems, but there is enough fresh water for many billions of people.

- a. True
- b. False

ANSWER: False

81. The solar nebula theory of the formation of the solar system accounts for the differences in composition between the terrestrial and Jovian planets.

- a. True
- b. False

ANSWER: True

82. The two types of crust are continental and oceanic.

- a. True
- b. False

ANSWER: True

83. Continental crust is thinner and denser than the oceanic crust.

- a. True
- b. False

ANSWER: False

84. According to the theory of organic evolution, all living organisms are related, and they descended with some modifications from organisms that lived in the past.

- a. True
- b. False

ANSWER: True

85. The central thesis of the theory of organic evolution is that there has always been the same diversity of species on Earth in the past as today.

- a. True
- b. False

ANSWER: False

86. Natural selection refers to survival of organisms that are best adapted to their environment.

- a. True
- b. False

ANSWER: True

87. In the 19th century, the geologic time scale was first developed using radiometric age dating techniques.

- a. True
- b. False

ANSWER: False

88. According to the principle of uniformitarianism, processes have occurred at different rates throughout geologic time.

- a. True
- b. False

ANSWER: True

89. In order for geologists to use the principle of uniformitarianism to interpret the geologic record, they do not need to study modern geologic processes.

a. True

b. False

ANSWER: False