

How Does Earth Work?, 2e (Smith/Pun)

Chapter 2 Minerals: Building Blocks of the Planet

2.1 Multiple Choice and True False Questions

1) Comparing the characteristics of two minerals, a student stated, "These two minerals are identical because they are both transparent and are six sided." Critique this statement.

A) This statement is true.

B) This statement is probably true, but the chemical composition would need to be known.

C) There are different types of six-sided crystals, so there is not enough information to say they are identical.

D) This statement is false.

Answer: C

Skill: Evaluation

Objective: 2.1

2) Identify the physical mineral property described.

"The fine-grained nature of the powdery residue results in a more reliable observed color."

A) cleavage

B) luster

C) streak

D) color

Answer: C

Skill: Comprehension

Objective: 2.1

3) A student breaks a piece of quartz and notices that it splits into irregular-shaped, jagged pieces, whereas calcite, when broken, will split into smooth, flat pieces. Which of the following properties of minerals is the student observing?

A) cleavage

B) luster

C) streak

D) color

Answer: A

Skill: Comprehension

Objective: 2.1

4) Identify the physical mineral property described.

"This property depends on the smoothness of the mineral surface at the atomic scale, or how mobile electrons are within the crystal."

- A) cleavage
- B) luster
- C) streak
- D) color

Answer: B

Skill: Comprehension

Objective: 2.1

5) What is the unit of increase on the Mohs Relative Hardness Scale?

- A) An increase of one unit indicates the rock is twice as hard as the one before.
- B) An increase of one unit indicates the rock is seven times as hard as the one before.
- C) An increase of one unit indicates the rock is ten times as hard as the one before.
- D) The scale is variable.

Answer: D

Skill: Analysis

Objective: 2.1

6) What is the relationship between density and specific gravity?

- A) They both have the same definition.
- B) They both represent the same dimensional units.
- C) They can have the same numerical value.
- D) They both measure substances in the same way.

Answer: C

Skill: Analysis

Objective: 2.1

7) What do muscovite and biotite have in common?

- A) They have identical chemical compositions.
- B) They are the same color.
- C) They have the same type of cleavage.
- D) They have the same luster.

Answer: C

Skill: Application

Objective: 2.1

8) Which of the following is true about quartz?

- A) It fractures in unpredictable patterns.
- B) It forms eight-sided crystals.
- C) It has two directions of cleavage.
- D) It has three directions of cleavage.

Answer: A

Skill: Comprehension

Objective: 2.1

9) How do geologists know that diamond is the hardest mineral?

- A) They conduct molecular analyses.
- B) They conduct a crush test.
- C) They conduct a scratch test.
- D) They conduct a streak test.

Answer: C

Skill: Analysis

Objective: 2.1

10) You find a rock and you think the mineral makeup is calcite. What evidence would indicate this?

- A) It is hard, therefore it is calcite.
- B) It breaks into 6-sided pieces, therefore it is calcite.
- C) It is pink, therefore it is calcite.
- D) It is very heavy, therefore it is calcite.

Answer: B

Skill: Knowledge

Objective: 2.1

11) Why does iron, when added to quartz, cause the purple color of amethyst?

- A) The presence of trace constituents can affect color.
- B) Iron overpowers the silicon in quartz.
- C) Amethyst is formed under extremely hot conditions.
- D) Iron is red and silicon is blue, making purple.

Answer: A

Skill: Knowledge

Objective: 2.2

12) Why are diamonds so hard?

- A) They are formed under very cold conditions.
- B) They are held together by strong metallic bonds.
- C) They are held together by strong ionic bonds.
- D) They are held together by strong covalent bonds.

Answer: D

Skill: Knowledge

Objective: 2.2

13) Which statement is true about the composition of minerals?

- A) Minerals are composed of elements.
- B) All minerals are compounds.
- C) There are no minerals composed of only one element.
- D) The chemical composition of a mineral does not determine the physical properties of the mineral.

Answer: A

Skill: Comprehension

Objective: 2.2

14) How does a TEM work?

- A) Electrons are shot at atoms; if they collide with electrons in the atoms, a shadow is made.
- B) A magnetic field moves electrons in a substance, leaving an impression.
- C) Light rays are shot at the electrons, and a microscopic camera takes a photograph of the result.
- D) Protons are shot at atoms; if they collide with electrons in the atoms, an shadow is made.

Answer: A

Skill: Comprehension

Objective: 2.3

15) Why do TEM images not form well in crystals with a random arrangement of atoms?

- A) With randomly arranged atoms, there is a greater chance that the electrons will miss the atoms, resulting in poor images.
- B) Crystals with random arrangements of atoms often have a more reflective surface, so the electrons bounce off the surface of the crystal, resulting in poor images.
- C) A random arrangement of atoms in a crystal means that the atoms are extremely small, resulting in poor images.
- D) A random arrangement of atoms in a crystal means that the atoms are extremely large, resulting in poor images.

Answer: A

Skill: Comprehension

Objective: 2.3

16) Why do "shadows" result in TEM images?

- A) Light does not pass through the atoms, resulting in shadows.
- B) Electrons are stopped by atoms, resulting in shadows.
- C) There are no objects for the electrons to hit, which results in shadows.
- D) Electrons pass through the atoms, resulting in shadows.

Answer: B

Skill: Analysis

Objective: 2.3

17) Carbon and oxygen atoms do not show up as well as calcium and magnesium atoms on a transmission electron microscope image of dolomite. Why?

- A) There are not as many carbon and oxygen atoms.
- B) Carbon and oxygen gases are transparent to light.
- C) The electrons are not as densely packed in carbon and oxygen.
- D) Transmission electron microscopes perform better on metals than nonmetals.

Answer: C

Skill: Analysis

Objective: 2.3

18) Critique the following statement made by a student looking at a TEM image of dolomite.
"The TEM image shows regular patterns of small dots, large dots, and tiny dots. The formula for dolomite is $\text{CaMg}[\text{CO}_3]_2$. I think the large dots must be the carbonate groups."

A) The student is correct.

B) The student is probably correct because four atoms will make a larger mark than one atom.

C) The student is probably incorrect because the single metal atoms have a denser arrangement of electrons than the carbonate group.

D) The student is incorrect because the image must not be dolomite. Since there are four types of atoms, the TEM for dolomite should have four sizes of dots.

Answer: C

Skill: Evaluation

Objective: 2.3

19) Why is water the universal solvent?

A) When cold, water breaks other molecules very easily.

B) When warm, water breaks other molecules very easily.

C) Molecules are slightly positively charged on one side and slightly negatively charged on the other.

D) Molecules are neutral all around.

Answer: C

Skill: Knowledge

Objective: 2.4

20) Which of the following is not a way that atoms achieve a full outer layer of electrons?

A) transferring electrons from an inner level

B) sharing electrons with another atom

C) transferring electrons to another atom

D) gaining extra electrons from another atom

Answer: A

Skill: Comprehension

Objective: 2.4

21) Freely roaming electrons in a material tend to make it a conductor of electricity. What other property do freely roaming electrons have an effect upon?

A) color

B) luster

C) cleavage

D) density

Answer: B

Skill: Comprehension

Objective: 2.4

22) What type of minerals dissolves best in water?

- A) metallically bonded minerals
- B) covalently bonded minerals
- C) ionically bonded minerals
- D) single-element minerals

Answer: C

Skill: Knowledge

Objective: 2.4

23) Covalent bonds are found in quartz. What could this suggest about its physical properties?

- A) It is a harder mineral.
- B) It is purple.
- C) It is malleable.
- D) It is a conductor of electricity.

Answer: A

Skill: Knowledge

Objective: 2.4

24) Ionic bonds are found in calcite. What could this suggest about its physical properties?

- A) It is bright white.
- B) It is malleable.
- C) It is a conductor of electricity.
- D) It is a softer mineral.

Answer: D

Skill: Knowledge

Objective: 2.4

25) Which of the following statements is not true about individual minerals?

- A) The composition of different minerals varies only slightly.
- B) Minerals can be produced by animals.
- C) Minerals have an ordered structure.
- D) Minerals can be synthetically manufactured.

Answer: D

Skill: Comprehension

Objective: 2.5

26) Which factor determines whether calcite or aragonite will form?

- A) temperature
- B) pressure
- C) time
- D) the atoms present

Answer: B

Skill: Application

Objective: 2.5

27) Graphite is a mineral but sugar is not. Why is this so?

- A) Sugar is naturally occurring, but graphite is manufactured.
- B) Graphite has an orderly arrangement of atoms, but sugar does not.
- C) Graphite is inorganic but sugar is organic.
- D) Sugar is not an important material for manufacturing.

Answer: C

Skill: Knowledge

Objective: 2.5

28) Why does graphite feel slippery to the touch?

- A) Graphite is soft and easily crushes into powder.
- B) Graphite atoms have many free electrons.
- C) Graphite absorbs water from the air so the surface always feels slippery.
- D) The carbon atoms in graphite are spaced closely together.

Answer: A

Skill: Application

Objective: 2.6

29) Why does manganese, when added to calcite, cause the mineral to turn a deep red?

- A) The presence of trace constituents can affect color.
- B) Manganese overpowers the calcium in calcite.
- C) Manganese is formed under extremely hot conditions.
- D) Manganese is red and calcium is white, making red.

Answer: A

Skill: Knowledge

Objective: 2.6

30) In order for an atom to substitute for dominant atoms in a crystal structure, and therefore alter its color, what must occur?

- A) The atom must be similar in size to the crystal's atoms.
- B) The atom must have the same charge as the crystal's atoms.
- C) The atom must be close in electronegativity values to the crystal's atoms.
- D) The atoms must be close to each other on the periodic table of elements.

Answer: A

Skill: Comprehension

Objective: 2.6

31) What factor increases the hardness of ionic substances?

- A) the presence of more free electrons
- B) an increased charge on the ions
- C) a decreased charge on the ions
- D) multiple bonds

Answer: B

Skill: Knowledge

Objective: 2.6

32) Which is not a factor that determines if bond strength will increase?

- A) close distance of atoms
- B) larger nuclei in atoms
- C) greater charge of particles
- D) larger size of molecules

Answer: D

Skill: Comprehension

Objective: 2.6

33) What variable will determine if light passes through diamond, but not through graphite?

- A) the amount of protons present
- B) the arrangement of the electrons
- C) the arrangement of the nuclei
- D) the color of the different bond types

Answer: B

Skill: Analysis

Objective: 2.6

34) How does bonding affect the hardness of a crystal?

- A) Covalently bonded crystals are harder than ionically bonded crystals.
- B) Ionically bonded crystals are harder than covalently bonded crystals.
- C) Some ionically bonded crystals are harder than covalently bonded crystals, depending on the charges of ions involved.
- D) Some covalently bonded crystals are harder than ionically bonded crystals.

Answer: D

Skill: Application

Objective: 2.6

35) From quartz's hard physical property, what can be inferred of its bonding structure?

- A) an interlocking three-dimensional framework of evenly spaced groups
- B) an interlocking three-dimensional framework of unevenly spaced groups
- C) two-dimensional sheets of hexagonally bonded groups, loosely bonded between sheets
- D) rhombically shaped ionic bonds between groups with even cleavage planes

Answer: A

Skill: Knowledge

Objective: 2.6

36) About how many minerals make up the majority of rocks on Earth's surface?

- A) 10
- B) 12
- C) 40
- D) 100

Answer: C

Skill: Comprehension

Objective: 2.7

37) What do the minerals gold, sulfur, and talc have in common?

- A) They are yellow in color.
- B) They are used almost as they are when removed from the ground.
- C) They are soft in texture.
- D) They are expensive to purchase.

Answer: B

Skill: Application

Objective: 2.7

38) How is the valuable part of an ore mineral removed?

- A) by heating the ore in boiling temperatures
- B) by breaking its mineral bonds
- C) by dissolving the ore in water and acid
- D) by using a magnet to remove the metal

Answer: B

Skill: Comprehension

Objective: 2.7

39) How many elements make up most of Earth's crust?

- A) 4
- B) 12
- C) 40
- D) 100

Answer: B

Skill: Knowledge

Objective: 2.7

40) How do mineral substitutions occur?

- A) If minerals deep within the Earth's surface melt, elements may mix together and substitute within mineral structures.
- B) If minerals in water dissolve, elements may mix together and substitute within mineral structures.
- C) Elements that do not have similar ionic charge or size often attract each other and substitute within mineral structures.
- D) Elements with similar ionic charge, size, or both substitute for each other within mineral structures.

Answer: D

Skill: Knowledge

Objective: 2.7

41) Why does lead have so many industrial uses?

- A) It is extremely cheap to mine and process.
- B) It has very strong bonds, making it a valuable hard mineral used for vehicles.
- C) It is a metal, and therefore is an excellent conductor of electricity and is used for power lines.
- D) It can be easily cast, molded, and shaped, as well as be used for its chemical properties in glazes, batteries, and gasoline.

Answer: D

Skill: Knowledge

Objective: 2.7

42) Most economically valuable metals are processed from

- A) ionic compounds.
- B) silicate ores.
- C) oxide and silicate ores.
- D) sulfide and oxide ores.

Answer: D

Skill: Comprehension

Objective: 2.7

43) True or False: Minerals are the fundamental building blocks of Earth.

Answer: TRUE

Skill: Knowledge

Objective: 2.0

44) True or False: Minerals form under a narrow range of physical and chemical conditions.

Answer: FALSE

Skill: Knowledge

Objective: 2.0

45) A mineral has the physical property of strong luster. What can be inferred about the elemental makeup?

- A) The mineral could be made up of nonmetals.
- B) The mineral could be made up of condensed liquids.
- C) The mineral could be made up of metals.
- D) The mineral could be made up of condensed gases.

Answer: C

Skill: Knowledge

Objective: 2.1

46) A mineral is labeled in the lab: $.5 \text{ kg/m}^3$. What could this value represent?

- A) specific gravity.
- B) hardness.
- C) luster.
- D) density.

Answer: D

Skill: Knowledge

Objective: 2.1

47) A mineral has a value of 8 on the Mohs hardness scale. What could this represent?

- A) The mineral is relatively hard.
- B) The mineral is the hardest of all minerals.
- C) The mineral is relatively soft.
- D) The mineral is the softest of all minerals.

Answer: A

Skill: Knowledge

Objective: 2.1

48) Two minerals are clearly different (based on hardness and cleave) but have the same color. What can be done to identify the minerals based on color?

- A) Submerge the minerals.
- B) Hit them with a hammer.
- C) Conduct a streak test.
- D) Weigh them.

Answer: C

Skill: Knowledge

Objective: 2.1

49) True or False: Color is always a reliable property for identifying a mineral.

Answer: FALSE

Skill: Knowledge

Objective: 2.1

50) True or False: A mineral may vary in color, but its streak color is always the same.

Answer: TRUE

Skill: Knowledge

Objective: 2.1

51) True or False: The Mohs hardness scale is a relative scale and not an absolute scale.

Answer: TRUE

Skill: Knowledge

Objective: 2.1

52) Diamond can cut through quartz. What does this suggest?

- A) Quartz is very weak.
- B) Diamond is very strong.
- C) Quartz is somewhat weak and diamond is somewhat strong.
- D) Both are very weak but diamond is only a bit strong.

Answer: B

Skill: Knowledge

Objective: 2.1

53) Which mineral property depends on bond type and the spacing of atoms within the crystal?

- A) density
- B) cleavage
- C) hardness
- D) streak

Answer: C

Skill: Knowledge

Objective: 2.1

54) True or False: The number of neutrons defines a particular element.

Answer: FALSE

Skill: Knowledge

Objective: 2.2

55) True or False: Each mineral has a definitive, but possibly slightly varying, chemical composition.

Answer: TRUE

Skill: Knowledge

Objective: 2.2

56) True or False: Ionic bonds, metallic bonds, or a mixture of both dominate most minerals.

Answer: FALSE

Skill: Knowledge

Objective: 2.4

57) Determine if cubic zirconia meets the definition of a mineral. If the substance doesn't meet the definition, specify which part of the definition doesn't apply.

- A) not a mineral because it's not a naturally occurring solid
- B) not a mineral because it's organic
- C) not a mineral because it doesn't possess a definite or slightly variable chemical composition
- D) not a mineral because it's not ordered atomic structure
- E) It's a mineral because it meets all the required characteristics.

Answer: A

Skill: Application

Objective: 2.5

58) True or False: Cleavage planes form where bonds are weakest in minerals.

Answer: TRUE

Skill: Knowledge

Objective: 2.6

59) True or False: Ionic bonds are stronger than covalent bonds.

Answer: FALSE

Skill: Knowledge

Objective: 2.6

60) True or False: All major rock forming minerals are silicates.

Answer: FALSE

Skill: Knowledge

Objective: 2.7

61) Of the 89 naturally occurring elements, how many are needed to account for 99.7 percent of the mass of Earth's crust?

A) 42

B) 21

C) 12

D) 10

Answer: C

Skill: Knowledge

Objective: 2.7

62) Calcite and halite are both held together by ionic bonds. Calcite has a +2 charge and halite a +1. Which is stronger?

A) halite

B) calcite

C) they are equally strong

D) they are equally weak

Answer: B

Skill: Comprehension

Objective: 2.3

63) One mineral is held together by van der Waal's forces and the other is held together by metallic bonds. Which is stronger?

A) They are equally strong.

B) They are equally weak.

C) The mineral held together by metallic bonds is stronger.

D) The mineral held together by van der Waal's forces is weaker.

Answer: C

Skill: Knowledge

Objective: 2.6

64) One mineral is held together by ionic bonds and the other by covalent bonds. Which is stronger?

- A) The one held together by covalent bonds is stronger.
- B) They are equally weak.
- C) The one held together by ionic bonds is stronger.
- D) They are equally strong.

Answer: A

Skill: Knowledge

Objective: 2.3

65) Which is a condition in which an element substitution could occur?

- A) an ion is much larger than the one it will replace
- B) an ion has a +4 charge, and it will replace an ion with a +3 charge
- C) an ion has an equal charge to the one it will replace
- D) an ion is much smaller than the one it will replace

Answer: C

Skill: Knowledge

Objective: 2.3

66) You boil water in a pot and find that there is a white coating lining the inside of the pot after you are done. What happened?

- A) The pot must have had a mineral in it already and water stirred it up.
- B) The pot was dirty.
- C) Water evaporated and left bacteria on the inside of the pot.
- D) The mineral precipitated from the water as the water boiled off as steam.

Answer: D

Skill: Analysis

Objective: 2.3

67) Separating lead, copper, zinc, and iron from the sulfur atoms produces sulfuric acid as a by-product. Why is this a problem?

- A) Sulfuric acid is useless and yields no profit.
- B) Sulfuric acid, when released into the atmosphere, combines with vapor to produce acid rain.
- C) Sulfuric acid is extremely profitable, but not in the form it is produced through this process.
- D) Lead, copper, zinc and iron are wasted in producing sulfuric acid, which is more profitable.

Answer: B

Skill: Comprehension

Objective: 2.7

68) Why is copper used for electrical wiring?

- A) It is an excellent conductor of electricity.
- B) It is very rigid.
- C) It has a metallic luster.
- D) It is rare, explaining why wiring is expensive.

Answer: A

Skill: Knowledge

Objective: 2.7

2.2 Short Answer Questions

1) Can you think of something that is not matter?

Answer: energy

2) Look up the chemical formula for the mineral graphite. Is it composed of molecules?

Answer: No.

3) Why don't electrons contribute anything to the mass of an atom?

Answer: They are too small.

4) If water were evaporating from a pan, would you expect the water molecules of ^{16}O or ^{18}O to evaporate first?

Answer: ^{16}O

5) How does being an isotope influence the charge of the atom?

Answer: It doesn't.

6) How many angstroms can you fit in an inch?

Answer: virtually zero

7) Why does the silica tetrahedron bond with one or more ions with a negative charge?

Answer: to gain electrochemical neutrality

8) What would happen if there were only three positive ions available to bond with a silica tetrahedron?

Answer: It would maintain a charge.

9) Which of the silicate structures would you expect to be the most stable and resistant to weathering at Earth's surface? Why?

Answer: quartz, pure silica

10) Where on the earth is olivine typically found?

Answer: near the mantle

11) Why is gemology considered a separate field from geology or mineralogy?

Answer: deals with sentimental/economic materials

12) What is corundum? If it is not in the rare form described here, do we use it for anything?

Answer: a hard mineral, sandpaper

13) You are a geologist hiking along a trail collecting rock samples. You come across a group of loose crystals which have broken away from the rocks, so you bring them back to the lab to figure out which minerals they could be. What tests can you put them through to figure out what they are? (2.1)

Answer: First, I would examine the color and luster of the crystals to narrow it down a bit. I would find the different masses of the minerals to determine their density and compare them to other specimens in textbooks. This would narrow my search down even more. Then, I would conduct the scratch test on the various minerals, scratching one another and ranking them in order, then comparing them to the Mohs Hardness Scale. After, I would examine the cleave of the mineral, and compare that to known minerals' cleaves. Last, I would find the streak of the minerals, and at this point, the minerals should be identified.

14) Why would a small amount of iron drastically change the color of quartz? (2.2)

Answer: The extremely small abundances of extra elements are insufficient to affect the properties shared by all specimens of quartz, such as density, luster, hardness, and cleavage. The presence of trace constituents, however, may affect color. Amethyst contains a tiny amount of iron, turning it purple. Therefore, chemical composition, within narrow ranges of variation, is another defining characteristic of individual minerals. It turns out that composition determines the physical properties of minerals. These properties are determined not only by which elements are present in each mineral, but also by how these elements combine with one another.

15) Under what conditions does a mineral most easily dissolve in water? (2.3)

Answer: A mineral dominated by ionic bonds dissolves easily in water. Adding acid to water further enhances solubility, because acids contain ions that draw atoms in minerals apart from one another.

16) What is different about metallic bonds? (2.3)

Answer: Electrons roam freely within metallic substances, accounting for their ability to conduct electricity and reflect rays of light. So, minerals with metallic bonds are said to have metallic luster, looking similar to bright, shiny metal. Copper, gold, and silver are examples of minerals□each consisting exclusively of the atoms of a single element□that exhibit metallic bonds.

17) Briefly describe the concept behind a TEM detector. (2.4)

Answer: Most of the size of an atom consists of the cloud of electrons that orbit the nucleus. If many electrons exist in a small area around the nucleus, then there is a good chance that electrons fired in the TEM will collide with an orbiting electron and bounce off it, rather than continuing through to the detector. If, however, the electrons are widely spaced around a nucleus, then the fired electrons may pass through the atom without hitting any obstacles. This means that the shadows in the TEM image may not represent all of the types of atoms in a mineral, but rather only the atoms with closely clustered electrons.

18) What constitutes a mineral? (2.5)

Answer: Only naturally formed substances are minerals; manufactured materials, such as synthetic gemstones (e.g., cubic zirconia), are not.

A mineral must be a solid with an orderly arrangement of atoms; it cannot be a gas or liquid. Opal, a popular gemstone, consists of silicon and oxygen, the same elements that compose quartz. Opal, however, lacks a highly ordered atomic structure and is not considered a mineral.

Organic compounds, those defined as containing mostly carbon and hydrogen atoms, are not minerals. Table sugar ($C_{12}H_{22}O_{11}$), therefore, is not a mineral, even though it is a naturally occurring solid with an orderly atomic structure.

The chemical composition of a particular type of mineral can vary slightly (as in the colored varieties of quartz illustrated in Figure 2.10), but the principal constituents are common to all specimens.

19) Why are diamonds so much harder than graphite if they both only consist of carbon atoms? (2.6)

Answer: Diamond and graphite consist only of carbon atoms, but their physical properties differ. Carbon atoms in diamond are closely spaced and share strong covalent bonds in all directions; this configuration produces the hardest mineral on Earth. The smooth crystal faces defining the external form of diamond coincide with planes of carbon atoms in the crystal structure. In graphite, however, carbon atoms are more widely spaced than in diamond and are strongly bonded only in two dimensions. The covalently bonded carbon sheets are weakly held together by van der Waals forces. The weakly linked sheets readily separate in graphite, accounting for its softness and its tendency to cleave readily into thin, scaly plates.

20) Which minerals are most important? (2.7)

Answer: Minerals are most important if they are common in rocks, provide essential resources, or both. Silicate minerals are the primary rock-forming minerals in the crust. More than 4,000 minerals have been identified, but only a few dozen are important as rock-forming minerals, because only 12 of the 89 naturally occurring elements compose 99.7 percent of Earth's crust. However, most economically valuable metals are processed from nonsilicate ore minerals, especially oxide and sulfide minerals, so not only silicate minerals are important!