

## CHAPTER 2

# ROCKS AND MINERALS — A FIRST LOOK

### Important Concepts

1. An *atom* is the smallest possible unit of an element that retains all the chemical characteristics of the element. The atom consists of a central *nucleus* and one or more negatively charged *electrons* in orbit around the nucleus. The nucleus consists of one or more positively charged *protons* and usually some electrically neutral particles called *neutrons*.
2. *Isotopes* are atoms of a given element (that is, with the same number of protons) that differ in the number of neutrons in their nuclei.
3. *Ions* are atoms that have lost or gained electrons. An atom that loses electrons becomes positively charged and is called a *cation*. An atom that gains electrons becomes negatively charged and is called an *anion*.
4. A *compound* is a chemical combination of two or more elements in specific proportions, and it has a distinct set of physical (and chemical) properties.
5. A *mineral* is a naturally occurring, inorganic, solid element or compound having definite chemical composition and a regular, characteristic crystal structure.
6. Physical properties of minerals include color, hardness (ability to resist scratching), density (mass per unit volume), and cleavage (tendency to split along certain planes of relatively weak bonding in the crystal).
7. Minerals can be classified into two broad groups: the silicates and the nonsilicates. *Silicates* are compounds of silicon and oxygen, usually with other elements as well. Examples of silicates include quartz, the feldspars, the ferromagnesian minerals, and the clay minerals. *Nonsilicates* are a diverse group of minerals that includes carbonates, sulfates, sulfides, oxides, hydroxides, halides, and native elements.
8. *Rocks* are cohesive solids composed of one or more minerals (and mineral materials, such as glass). There are three categories of rocks:
  - (a) *Igneous* rocks are formed by the solidification and crystallization of a cooling *magma*. *Plutonic* igneous rocks form from magmas that cool slowly at depth and are typically coarse-grained. *Volcanic* igneous rocks form at or very close to the earth's surface, and their rapid cooling and solidification usually result in fine-grained textures.
  - (b) *Sedimentary* rocks are formed from sediments at low temperatures. *Clastic* sedimentary rocks are formed from fragments of preexisting rocks; examples include sandstone, shale, and conglomerate. *Chemical* sedimentary rocks are formed by direct precipitation of minerals from solution; examples include limestone and rock salt.
  - (c) *Metamorphic* rocks are formed by the recrystallization of preexisting rocks that were subjected to heat and/or pressure. Examples include marble, quartzite, slate, schist, and gneiss.
9. All rocks are transformed over time into new rocks through various geologic processes. This concept of interrelation among the different types of rocks is known as the *rock cycle*.

## Key Terms

anion	lava
atom	lithification
atomic mass number	magma
atomic number	metamorphic
carbonate	mineral
cation	Mohs hardness scale
chemical sedimentary rock	native element
clastic sedimentary rock	neutron
cleavage	nucleus
compound	oxide
contact metamorphism	periodic table
covalent bonding	plutonic
crystalline	proton
electron	regional metamorphism
ferromagnesian	rock
foliation	rock cycle
glass	sediment
hardness	sedimentary
igneous	silicate
ion	sulfate
ionic bonding	sulfide
isotope	volcanic

## Multiple Choice

1. The number of naturally occurring chemical elements is approximately
  - a. 36.
  - b. 90.
  - c. 106.
  - d. 200.
2. Electrons are
  - a. found within atomic nuclei.
  - b. electrically neutral.
  - c. positively charged.
  - d. negatively charged.
3. An element's chemical identity is determined by its
  - a. number of isotopes.
  - b. atomic number.
  - c. number of neutrons.
  - d. atomic mass number.
4. Isotopes of the same element
  - a. differ in atomic number.
  - b. have different atomic mass numbers.
  - c. differ in their number of electrons.
  - d. differ in their chemical behavior.

5. Which of the following physical properties is not a reliable guide to mineral identification in hand specimens?
- hardness
  - cleavage
  - color
  - streak
6. The atomic number of the element oxygen (O) is 8. If it gains two electrons to form an anion, what will be the electrical charge of this anion?
- 1
  - 2
  - + 1
  - + 2
7. Which of the following is a good example of a chemical sedimentary rock?
- sandstone
  - basalt
  - marble
  - limestone
8. An atom of a certain isotope of carbon has 6 protons, 6 electrons, and 8 neutrons. Its atomic mass number is
- 6.
  - 12.
  - 14.
  - 20.
9. In an electrically neutral atom,
- electrons and protons have no charge.
  - the electron shells are completely filled.
  - the number of protons and the number of electrons are the same.
  - the number of neutrons is equal to the sum of the number of protons and electrons.
10. Ionic bonding occurs when
- atoms share electrons.
  - ions share electrons.
  - atomic nuclei gain or lose protons.
  - oppositely charged ions attract each other.
11. All of the following statements concerning minerals are correct except
- minerals are crystalline solids.
  - some minerals are produced by biological processes.
  - minerals are naturally occurring substances.
  - minerals exist as elements or compounds.
12. The two fundamental characteristics that distinguish a mineral from all other minerals are its
- color and hardness.
  - hardness and cleavage.
  - chemical composition and crystal structure.
  - density and shape.

13. Which one of the following compounds contains three elements and six atoms?
- $\text{CaCO}_3$
  - $\text{Na}_2\text{SO}_4$
  - $\text{PbSO}_4$
  - $\text{Fe}_2\text{O}_3$
14. The tendency of a mineral to break apart preferentially in certain directions, depending on its crystalline structure, is known as
- hardness.
  - cleavage.
  - fracture.
  - splitting.
15. The correct sequence of minerals arranged in order of increasing hardness is
- corundum, apatite, topaz, diamond.
  - talc, calcite, quartz, corundum.
  - apatite, gypsum, topaz, quartz.
  - fluorite, talc, calcite, orthoclase.
16. The most abundant group of minerals in the earth's crust is the
- ferromagnesian minerals.
  - feldspars.
  - clays.
  - carbonates.
17. Ferromagnesian minerals belong to the \_\_\_\_\_ group of minerals.
- silicate
  - carbonate
  - oxide
  - sulfide
18. An example of a plutonic igneous rock is
- basalt.
  - obsidian (volcanic glass).
  - granite.
  - porphyry.
19. All of the following are examples of clastic sedimentary rocks except
- conglomerate.
  - shale.
  - sandstone.
  - limestone.
20. Metamorphosed limestone is called
- slate.
  - gneiss.
  - marble.
  - quartzite.

## Fill In the Blanks

1. An \_\_\_\_\_ is the smallest particle into which an element can be subdivided while still retaining the chemical characteristics of that element.
2. The atomic number is the number of \_\_\_\_\_ in an atomic nucleus.
3. The atomic \_\_\_\_\_ number is the sum of the number of protons and the number of neutrons in an atomic nucleus.
4. An \_\_\_\_\_ is an atom that has lost or gained electrons.
5. \_\_\_\_\_ bonding occurs when the atoms of a compound share electrons.
6. A \_\_\_\_\_ is a chemical combination of two or more elements, in specific proportions, having a distinctive set of physical properties.
7. The atoms of \_\_\_\_\_ materials are arranged in regular, repeating patterns.
8. \_\_\_\_\_ is the ability of a mineral to resist scratching.
9. The silica \_\_\_\_\_, consisting of four oxygen anions surrounding a single silicon cation, is the basic building block of silicate minerals.
10. \_\_\_\_\_ are silicates in which atoms are tightly bonded into two-dimensional sheets.
11. \_\_\_\_\_ is the simplest silicate containing only silicon and oxygen.
12. \_\_\_\_\_ are unusual among silicates in that their structures can absorb or lose water.
13. \_\_\_\_\_ is a naturally occurring silicate melt, which may also contain suspended mineral crystals and dissolved water and gases.
14. \_\_\_\_\_ sedimentary rocks are those formed from fragments of preexisting rocks.
15. \_\_\_\_\_ metamorphism occurs adjacent to a cooling magma body, while \_\_\_\_\_ metamorphism occurs on a large scale involving heat and pressure generated by mountain-building or plate-tectonic movement.

## True or False

Indicate whether the following statements are true or false. If false, correct the statement to make it true.

- \_\_\_\_\_ 1. Cations are negatively charged ions; anions are positively charged ions.
- \_\_\_\_\_ 2. The symbols for some elements, such as Fe for iron and Pb for lead, are derived from the Latin names for these elements.

- \_\_\_\_\_ 3. Color is one of the best physical properties to use in the identification of a mineral.
- \_\_\_\_\_ 4. Most minerals are oxides.
- \_\_\_\_\_ 5. The economically important minerals of many metals are sulfides.
- \_\_\_\_\_ 6. Calcite is the most abundant carbonate mineral and is an important constituent of limestone and marble.
- \_\_\_\_\_ 7. Sulfur, gold, and graphite are examples of native elements.
- \_\_\_\_\_ 8. Magmas that crystallize rapidly produce igneous rocks characterized by large mineral crystals.
- \_\_\_\_\_ 9. Typical examples of metamorphic rocks that exhibit foliation include marble and quartzite.
- \_\_\_\_\_ 10. The rock cycle is a consequence of the continually changing geologic environment.

### Matching

Match the following mineral groups with their correct compositional description.

- |                        |  |
|------------------------|--|
| ___ 1. Carbonates      | a. contain a metal plus fluorine, chlorine, bromine, or iodine             |
| ___ 2. Sulfates        | b. contain one or more metals plus carbon and oxygen in the ratio of 1:3   |
| ___ 3. Oxides          | c. contain one or more metals plus oxygen                                  |
| ___ 4. Hydroxides      | d. contain one or more metals plus hydrogen and oxygen in the ratio of 1:1 |
| ___ 5. Sulfides        | e. contain one or more metals plus sulfur and oxygen in the ratio of 1:4   |
| ___ 6. Halides         | f. consist of a single element   |
| ___ 7. Native elements | g. contain one or more metals plus sulfur without oxygen                   |

## Review Questions

1. What are isotopes? Explain using U-238 and U-235 as examples.
2. What are the three broad categories of rocks, and how do they differ from each other?
3. Give an example of each of the following kinds of rocks:
  - (a) plutonic igneous rock —
  - (b) volcanic igneous rock —
  - (c) chemical sedimentary rock —
  - (d) clastic sedimentary rock —
  - (e) metamorphic rock —
4. Draw a sketch illustrating the rock cycle. Why do we call it a “cycle”?

## Surfing the Net

A collection of images of and information about many minerals (The Mineral Gallery):  
<<http://www.theimage.com/mineral/minerals1.html>>

Pictures of microscopic views of thin slices of igneous and metamorphic rocks revealing interesting textural details (University of North Carolina):  
<<http://www.geolab.unc.edu/Petunia/IgMetAtlas/mainmenu.html>>

## CHAPTER 2 ANSWER KEY

### Multiple Choice

- |      |       |                    |       |
|------|-------|--------------------|-------|
| 1. b | 6. b  | 11. b              | 16. b |
| 2. d | 7. d  | 12. c              | 17. a |
| 3. b | 8. c  | 13. c              | 18. c |
| 4. b | 9. c  | 14. b (figure 2.5) | 19. d |
| 5. c | 10. d | 15. b (table 2.1)  | 20. c |

### Fill In the Blanks

- |                |                        |
|----------------|------------------------|
| 1. atom        | 9. tetrahedron         |
| 2. protons     | 10. Micas (figure 2.5) |
| 3. mass        | 11. Quartz             |
| 4. ion         | 12. Clays              |
| 5. Covalent    | 13. Magma              |
| 6. compound    | 14. Clastic            |
| 7. crystalline | 15. Contact, regional  |
| 8. Hardness    |                        |

### True or False

1. False. Anions are negatively charged ions; cations are positively charged ions.
2. True
3. False. The color of a mineral can sometimes vary from specimen to specimen due to trace impurities. Also, different minerals can sometimes have the same color.
4. False. Most minerals belong to the silicate group.
5. True
6. True
7. True
8. False. Magmas that crystallize rapidly typically produce fine-grained igneous rocks.
9. False. Examples of foliated metamorphic rocks include slate, schist, and gneiss.
10. True

### Matching (see table 2.2)

1. b    2. e    3. c    4. d    5. g    6. a    7. f