Answer Key

Answers to Study Questions

1. a. An *element* is a substance that cannot be broken down into simpler substances by ordinary chemical means.

   b. An *atom* is the smallest fraction of an element that can exist and still show the characteristics of that element. The main building blocks of an atom are protons, neutrons, and electrons.

   c. An *ion* is an electrically-charged atom or group of atoms.

   d. *Isotopes* are atoms of the same element that have the same number of protons but different numbers of neutrons.

2. *Atomic mass number* is the total number of neutrons and protons in an atom; *atomic number* is the number of protons in each atom of an element; *atomic weight* is the weight of an average atom of an element. The atomic weight is usually not an integer, because atomic weight is a mathematical average of the weights of all isotopes of an element according to the frequency with which each occurs.

3. a. A proton is an atomic particle with a positive electrical charge. Protons occur in the nucleus of an atom, and each proton has a mass number of about 1850 times that of an electron. Each atom of an element has the same number of protons.

   b. A neutron is an atomic particle with neutral electrical charge. Neutrons occur in the nucleus of an atom, and have a mass approximately equal to that of protons. The number of neutrons differs in different isotopes of an element.

   c. An electron is a negatively-charged atomic particle. Electrons are very tiny, and move around the nucleus of an atom in defined energy "shells."

4. An atom that loses or gains an electron becomes charged with a positive or negative charge that is called an *ion*.

5. If an electron is removed from an atom, the atom becomes a positively charged ion: a cation. If an electron is added to an atom, the atom becomes a negatively charged ion: an anion.

6.

Element	Electrons in the outer shell	Charge in most stable ionic form
Li	1	+1
O	6	–2
Mg	2	+2
K	1	+1
Al	3	+3
Cl	7	–1

7. Four types of bonds are commonly found in minerals:
   - In ionic bonding, electrons are exchanged between atoms or molecules, and the aggregate is held together by electrostatic attraction.
   - In covalent bonding, electrons are shared between the atoms that are bound together.
   - In metallic bonding, electrons from each atom move freely in a cloud within the aggregate.
   - In Van der Waals bonds, a weak electrostatic attraction occurs because of distortion of certain atoms and ions from a spherical shape.

8. A *solid* is a substance in which atoms are arranged in a rigid framework.

   A *liquid* is a substance in which particles are in random motion, but are packed close together.

   A *gas* is a substance in which particles are in rapid motion and in which atoms or molecules are separated by empty spaces and are (comparatively) far apart.

9. A crystalline substance is one in which the atoms are arranged in a regular, repeating, and orderly pattern.

10. A silicate mineral is a mineral that contains a combination of oxygen plus silicon as part of its chemical formula. Quartz is a silicate mineral with the formula SiO_2.

11. Compare your diagram to Figure 2.10 of the textbook. The basic building block of silicate minerals is the silicon-oxygen tetrahedron. It is called this because the four large oxide ions form a four-sided pyramid.

12. The four fundamental configurations of tetrahedral groups in silicate minerals are single chains (e.g., augite), double chains (e.g., hornblende), two-dimensional sheets (e.g., mica), and three-dimensional frameworks (e.g., quartz, feldspar).

13. Clay minerals are sheet silicate minerals similar to mica, but their crystals are microscopic.

14. To be considered a mineral, a substance must

    - be a crystalline solid,
    - occur naturally,
    - be inorganic, and
    - have a chemical composition that varies within definite limits.

15. In all crystals of a given substance, the angle between two adjacent faces is always the same, even though the size and shape of the crystals may vary.

16. Polymorphism is the ability of a specific chemical substance to crystallize with more than one type of structure; that is, different structural arrangements of the same elements produce different minerals. For example, FeS2 forms pyrite when in a cubic form, and marcasite when in an orthorhombic form; C forms diamond when in a cubic form and graphite when in a hexagonal form.

17. Ionic substitution is a process whereby one or more ions substitute for each other within a mineral structure. The mineral undergoes a chemical change, but there is no change in the crystal structure.

18. The most important factors determining the ability of one ion to substitute for another are size and electrical charge on the ions. Ionic radii must differ by less than 15%, and the total charge of the mineral must remain neutral (hence, in the substitution of an ion of a different charge, other substitutions, also involving charge differences, must compensate).

19. A mineral group is a group of minerals that have the same structure but varying composition, and a resulting limited range in physical properties. Examples include feldspars, pyroxenes, amphiboles, and micas.

20. Six significant and observable physical properties of minerals are crystal form, cleavage, hardness, specific gravity, colour, and streak.

21. Cleavage is the tendency of a crystalline substance to split or break along smooth planes parallel to zones of weak bonding in the crystal structure.

22. See Figure 2.18 in the textbook regarding Mohs' hardness scale. Each mineral of increasing hardness can be used to scratch the minerals with a lower degree of hardness. Since each mineral has a characteristic hardness, this property can be used in preliminary mineral identification.

23. Specific gravity is the ratio of the weight of a given volume of a substance to the weight of an equal volume of water. Specific gravity depends on the number of atoms and the compactness of these atoms.

24. Samples of different colours aren't necessarily different minerals. For example, quartz can have many different colours.

25. Streak is the colour of the powdered form of a mineral.

26. a. Magma is molten rock. In a sense, it is both the beginning and the end of the rock cycle, as igneous rock forms from magma, and igneous, sedimentary, or metamorphic rocks that melt become magma again.

    b. Igneous rocks form when magma solidifies.

    c. Debris from the weathering of igneous rock is transported and deposited as sediment.

    d. Sedimentary rock is lithified sediment.

    e. Metamorphic rock is a product of high temperature and pressure acting on rock that has been buried several kilometres below the surface of the Earth.