Chapter 10: Volcanoes and Other Igneous Activity
Section 1: The Nature of Volcanic Eruptions

I. Factors Affecting Eruptions
Main Idea:

A. Viscosity
Main Idea:

B. Dissolved Gases
Main Idea:

II. Volcanic Material
Main Idea:

A. Lava Flows
Main Idea:

B. Gases
Main Idea:

C. Pyroclastic Materials
Main Idea:

III. Types of Volcanoes
Main Idea:

A. Anatomy of a Volcano
Main Idea:

B. Shield Volcanoes
Main Idea:

C. Cinder Cones
Main Idea:

D. Composite Cones
Main Idea:
E. Dangers from Composite Cones
Main Idea:

IV. Other Volcanic Landforms
Main Idea:

A. Calderas
Main Idea:

B. Necks and Pipes
Main Idea:

C. Lava Plateaus
Main Idea:

Section 2: Intrusive Igneous Activity

I. Plutons
Main Idea:

A. Sills and Laccoliths
Main Idea:

B. Dikes
Main Idea:

C. Batholiths
Main Idea:

II. Origin of Magma
Main Idea:

A. Role of Heat
Main Idea:

B. Role of Pressure
Main Idea:
Section 3: Plate Tectonics and Igneous Activity

I. Convergent Plate Boundaries
   A. Ocean-Ocean
   B. Ocean-Continent

II. Divergent Plate Boundaries

III. Intraplate Igneous Activity
Chapter 11: Mountain Building

Section 1: Rock Deformation

I. Factors Affecting Deformation
   Main Idea:

   A. Temperature and Pressure
      Main Idea:

   B. Rock Type
      Main Idea:

   C. Time
      Main Idea:

II. Types of Stress
    Main Idea:

III. Folds
     Main Idea:

   A. Anticlines
      Main Idea:

   B. Synclines
      Main Idea:

   C. Monoclines
      Main Idea:

   D. Normal Faults
      Main Idea:

   E. Reverse Faults and Thrust Faults
      Main Idea:

   F. Strike-Slip Faults
      Main Idea:

   G. Joints
Section 2: Types of Mountains
I. Folded Mountains
   Main Idea:
II. Fault-Block Mountains
    Main Idea:
III. Domes and Basins
     Main Idea:

Section 3: Mountain Formation
I. Mountain Building at Convergent Boundaries
   Main Idea:
   A. Ocean-Ocean Convergence
      Main Idea:
   B. Ocean-Continental Convergence
      Main Idea:
   C. Continent-Continent Convergence
      Main Idea:
II. Mountain Building at Divergent Boundaries
    Main Idea:
III. Non-Boundary Mountains
     Main Idea:
IV. Continental Accretion
    Main Idea:
    A. Terranes
       Main Idea:
    B. Mountains from Accretion
       Main Idea:
V. Principle of Isostasy
   Main Idea:

   A. Isostatic Adjustment for Mountains
   Main Idea:
Section 10.1 The Nature of Volcanic Eruptions

This section discusses volcanic eruptions, types of volcanoes, and other volcanic landforms.

Reading Strategy

Previewing: Before you read the section, rewrite the green topic headings as questions. As you read, write the answers to the questions. For more information on this Reading Strategy, see the Reading and Study Skills in the Skills and Reference Handbook at the end of your textbook.

The Nature of Volcanic Eruptions

<table>
<thead>
<tr>
<th>What factors affect an eruption?</th>
<th>a.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Factors Affecting Eruptions

1. ☰ What are three factors that determine how violently or quietly a volcano erupts?
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

2. Circle the letter of the term that describes lava’s resistance to flow.
   a. temperature
   b. eruption
   c. viscosity
   d. basaltic

Volcanic Material

3. Is the following sentence true or false? One thing all volcanic eruptions have in common is that they emit large amounts of gas.
   ____________________________________________________________

4. ☰ During a volcanic eruption, particles called ____________________, ranging from very fine dust to pieces weighing several tons, are ejected.
Chapter 10  Volcanoes and Other Igneous Activity

Types of Volcanoes

5. Select the appropriate letter in the figure that identifies each of the following types of volcanoes.

A. shield volcano  B. cinder cone  C. composite cone

6. The steep-walled depression known as a(n) ________________ is located at the summit of many volcanoes.

7. Circle the letter of the type of volcano that is the product of gas-rich basaltic magma mostly in the form of loose pyroclastic material.
   a. cinder cone  b. shield volcano  c. stratovolcano  d. composite cone

8. Is the following sentence true or false? Cinder cones are the most potentially dangerous volcanoes because they generate the most explosive eruptions. ________________

Other Volcanic Landforms

Match each description with its volcanic landform or feature.

<table>
<thead>
<tr>
<th>Description</th>
<th>Volcanic Landform or Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>conduit that feeds magma to a volcano’s surface</td>
<td>a. caldera</td>
</tr>
<tr>
<td>wide area that forms when low-viscosity basaltic lava flows from fissures</td>
<td>b. pipe</td>
</tr>
<tr>
<td>rock conduit that remains when the surrounding cone has been eroded</td>
<td>c. lava plateau</td>
</tr>
<tr>
<td>depression formed by the collapse of the top of a volcano</td>
<td>d. volcanic neck</td>
</tr>
</tbody>
</table>
Section 10.2 Intrusive Igneous Activity

This section explains how to classify intrusive igneous features and describes where magma comes from.

Reading Strategy

Comparing and Contrasting After you read, compare the types of plutons by completing the table. For more information on this Reading Strategy, see the Reading and Study Skills in the Skills and Reference Handbook at the end of your textbook.

<table>
<thead>
<tr>
<th>Types of Plutons</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sill</td>
<td>a.</td>
</tr>
<tr>
<td>Laccolith</td>
<td>b.</td>
</tr>
<tr>
<td>Dike</td>
<td>c.</td>
</tr>
<tr>
<td>Bathololith</td>
<td>d.</td>
</tr>
</tbody>
</table>

Plutons

1. Select the appropriate letter in the diagram that identifies each of the following igneous intrusive features.

   _____ sill
   _____ batholith
   _____ laccolith
   _____ dike

2. Is the following sentence true or false? Plutons can be studied on Earth’s surface as they form.

   ____________________
Chapter 10  Volcanoes and Other Igneous Activity

3. ☐ What three characteristics are used to classify intrusive igneous bodies?

Match each way plutons formed with the pluton type.

<table>
<thead>
<tr>
<th>How Formed</th>
<th>Pluton</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. when magma from a large magma chamber invades fractures in the surrounding rocks</td>
<td>a. sill</td>
</tr>
<tr>
<td>5. when a large intrusive igneous body of greater than 100 km² accumulates and becomes exposed</td>
<td>b. laccolith</td>
</tr>
<tr>
<td>6. when magma is injected between sedimentary layers close to Earth’s surface and collects as a lens-shaped mass</td>
<td>c. batholith</td>
</tr>
<tr>
<td>7. when magma is injected along sedimentary bedding surfaces close to Earth’s surface</td>
<td>d. dike</td>
</tr>
</tbody>
</table>

Origin of Magma

8. ☐ Is the following sentence true or false? Magma forms when solid rock in the crust and upper mantle partially melts.

9. ☐ Circle the letter of one way magma is generated.
   a. The confining pressure of rocks is increased.
   b. The water content of rocks is reduced.
   c. The temperature of rocks is lowered below their melting points.
   d. The temperature of rocks is raised above their melting points.

10. The rate at which temperature changes with depth below Earth’s surface is called the _________________.

11. How is decompression melting of rocks triggered? ________________

12. ________________ rock buried at depth has a much lower melting temperature than does ________________ rock of the same composition and under the same pressure.
Section 10.3 Plate Tectonics and Igneous Activity

This section discusses the relationship between plate boundaries and igneous activity.

Reading Strategy

Outlining After you read, complete the outline of the most important ideas in the section. For more information on this Reading Strategy, see the Reading and Study Skills in the Skills and Reference Handbook at the end of your textbook.

I. Plate Tectonics and Igneous Activity
   A. Convergent Plate Boundaries
      1. 
      2. 
   B. 
   C. 

Convergent Plate Boundaries

1. What provides the mechanism by which mantle rocks melt and magma is produced? 

2. Circle the letter of the change that allows rock melting to begin at convergent plate boundaries.
   a. decreasing pressure
   b. decreasing temperature
   c. water reducing the melting point
   d. water raising the melting point

3. What landforms develop as a result of the volcanic activity that occurs where one oceanic plate descends beneath another oceanic plate? 

4. Is the following sentence true or false? At ocean-continent plate boundaries, rising magma may change composition before reaching the surface. 

5. Circle the letter of the answer that correctly completes the following sentence. At a convergent plate boundary, the fluids reduce the melting point of hot mantle rock enough for melting to begin when a sinking slab reaches a depth of about
   a. 100 to 150 km. 
   b. 500 to 550 km. 
   c. 700 to 750 km. 
   d. 1000 to 1500 km.
Chapter 10  Volcanoes and Other Igneous Activity

Divergent Plate Boundaries

6. Most magma is produced along _____________ plate boundaries.

7. Is the following sentence true or false? When solid mantle rock rises during seafloor spreading, magma is produced as a result of decompression melting. _____________

8. Why does the newly formed magma at divergent plate boundaries rise to the surface? _____________

Intraplate Igneous Activity

9. Complete the concept map showing where intraplate volcanism occurs.

10. Circle the letter of the time most intraplate volcanism occurs.
    a. when oceanic crust sinks into the mantle and melts
    b. when a mantle plume rises to the surface
    c. when oceanic plates separate and magma rises to fill the rift
    d. when continental crust sinks into the mantle and melts

11. The result of a magma plume rising and decompression melting occurring may be the formation of a small volcanic region called a(n) _____________.

12. Circle the letter of the number of years most hot spots have lasted.
    a. hundreds of years  b. thousands of years
    c. millions of years d. billions of years
Section 11.1 Rock Deformation

This section explains how rocks are deformed.

Reading Strategy

Comparing and Contrasting  As you read this section, compare types of faults by completing the table below. For more information on this Reading Strategy, see the Reading and Study Skills in the Skills and Reference Handbook at the end of your textbook.

<table>
<thead>
<tr>
<th>Types of Fault</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal fault</td>
<td>a.</td>
</tr>
<tr>
<td></td>
<td>b.</td>
</tr>
<tr>
<td></td>
<td>c.</td>
</tr>
<tr>
<td></td>
<td>d.</td>
</tr>
<tr>
<td></td>
<td>e.</td>
</tr>
<tr>
<td></td>
<td>f.</td>
</tr>
</tbody>
</table>

Factors Affecting Deformation

Match each definition to its term.

<table>
<thead>
<tr>
<th>Definition</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. the force per unit area acting on a solid</td>
<td>a.</td>
</tr>
<tr>
<td>2. the change in shape or volume of a body of rock as a result of stress</td>
<td>b.</td>
</tr>
<tr>
<td>3. a general term that refers to all changes in the original shape and/or size of a body of rock</td>
<td>c.</td>
</tr>
</tbody>
</table>

4. What are the four factors that influence the strength of a rock and how it will deform?  

5. What are the two ways rocks permanently deform?
Chapter 11 Mountain Building

6. Circle the letters of the statements that are true about rock deformation.
   a. Ductile deformation is strongly aided by high temperature and high confining pressure.
   b. Small stresses applied over time play an important role in rock deformation.
   c. The mineral composition and texture of a rock affects how it will deform.
   d. Rocks near the surface usually undergo ductile deformation.

Types of Stress
7. What are the three types of stresses that rocks commonly undergo?

Folds

Match each definition to its term.

<table>
<thead>
<tr>
<th>Definition</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. large, step-like folds in otherwise horizontal sedimentary strata</td>
<td>a. anticlines</td>
</tr>
<tr>
<td>9. upfolding, or arching, of rock layers</td>
<td>b. synclines</td>
</tr>
<tr>
<td>10. downfolds or troughs</td>
<td>c. monoclines</td>
</tr>
</tbody>
</table>

11. Briefly describe each of the following types of faults and select the appropriate letter in the figure that identifies each fault.
   
   Reverse fault: ____________________________
   Strike-slip fault: _______________________
   Normal fault: ____________________________
   Thrust fault: ____________________________

   ![Diagram of fault types]
Section 11.2 Types of Mountains

This section explains the characteristics of various types of mountains.

Reading Strategy

Previewing  Rewrite the green topic headings as questions in the table below. As you read, write answers to the questions. For more information on this Reading Strategy, see the Reading and Study Skills in the Skills and Reference Handbook at the end of your textbook.

<table>
<thead>
<tr>
<th>Types of Mountains</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are folded mountains?</td>
</tr>
<tr>
<td>a.</td>
</tr>
<tr>
<td>b.</td>
</tr>
<tr>
<td>c.</td>
</tr>
<tr>
<td>d.</td>
</tr>
<tr>
<td>e.</td>
</tr>
<tr>
<td>f.</td>
</tr>
<tr>
<td>g.</td>
</tr>
<tr>
<td>h.</td>
</tr>
<tr>
<td>i.</td>
</tr>
</tbody>
</table>

Folded Mountains

Match each definition to its term.

<table>
<thead>
<tr>
<th>Definition</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. mountains formed primarily by folding</td>
<td>a. orogenesis</td>
</tr>
<tr>
<td>2. the collection of processes that produce a mountain belt</td>
<td>b. folded mountains</td>
</tr>
<tr>
<td>3. the major force that forms folded mountains</td>
<td>c. compressional forces</td>
</tr>
</tbody>
</table>

4. __________________________ is also important in the formation of folded mountains, which are often called fold-and-thrust belts.

5. Circle the letter of the mountain ranges that are examples of folded mountains.
   a. Appalachian Mountains
   b. northern Rocky Mountains
   c. Teton Range in Wyoming
   d. the Alps in Europe
Chapter 11  Mountain Building

Fault-Block Mountains
6. Select the letter from the figure that identifies each formation.
   _____ graben   _____ horst

7. Which type of fault is illustrated in the figure? ________________

8. Circle the letter of each true statement about fault-block mountains.
   a. Normal faulting occurs where tensional stresses cause the crust to be stretched.
   b. Grabens produce an elongated valley bordered by horsts.
   c. The Appalachian Mountains are examples of fault-block mountains.
   d. The Basin and Range Province of Nevada, Utah, and California are made of elongated grabens.

Domes and Basins
9. When upwarping produces a circular or an elongated structure, the feature is called a(n) ________________.

10. Is the following sentence true or false? The Black Hills of western South Dakota make up a large domed structure thought to be formed by upwarping. ________________

11. Circle the letter of each statement that is true about domes and basins.
   a. Broad upwarping in basement rock may deform the overlying cover of sedimentary strata, generating large folds.
   b. The oldest rocks form the core in a dome.
   c. The youngest rocks are found near the center in a basin.
   d. The Black Hills of South Dakota make up a large domed structure.

12. Is the following sentence true or false? The Black Hills of South Dakota contain exposed igneous and metamorphic rock in the center of a dome. ________________
Section 11.3 Mountain Formation
This section explains how mountains are formed at plate boundaries.

Reading Strategy
Outlining  As you read, make an outline of the important ideas in this section. Use the green topic headings as the main topics and the blue headings as subtopics. For more information on this Reading Strategy, see the Reading and Study Skills in the Skills and Reference Handbook at the end of your textbook.

I. Mountain Formation
   A. Mountain Building at Convergent Boundaries
      1. Ocean-Ocean Convergence
      2. 
      3. 
   B. Mountain Building at Convergent Boundaries
   C. 
   D. 
      1. 
      2. 
   E. 
      1. 

Mountain Building at Convergent Boundaries
1. ☐ Is the following sentence true or false? Most mountain building occurs at convergent plate boundaries. ________________
2. ☐ ________________ provide the compressional forces that fold, fault, and metamorphose the thick layers of sediment deposited at the edges of landmasses.
3. Circle the letter of each true statement about ocean-ocean convergence.
   a. Ocean-ocean convergence occurs when an oceanic plate converges with a continental plate.
   b. The converging plates can lead to the growth of a volcanic island arc on the ocean floor.
   c. An example of an island arc formed by ocean-ocean convergence is the Aleutian Islands in Alaska.
   d. Ocean-ocean convergence mainly produces volcanic mountains.
4. ☐ Is the following sentence true or false? The types of mountains formed by ocean-continental convergence are volcanic mountains and folded mountains. ________________
5. The figure illustrates mountain building along an Andean-type subduction zone. Select the appropriate letter in the figure that identifies each of the following features.

____ ocean trench
____ asthenosphere
____ continental volcanic arc
____ accretionary wedge
____ subducting oceanic lithosphere

6. Is the following sentence true or false? At a convergent boundary between two plates carrying continental crust, a collision between the continental fragments will result in the formation of folded mountains. ________________

Mountain Building at Divergent Boundaries

7. ________________ mountains are formed along ocean ridges at divergent plate boundaries.

Non-Boundary Mountains

8. Why are some mountains forming at non-plate boundaries?

________________________________________________________

________________________________________________________

Continental Accretion

9. When crustal fragments collide with a continental plate, they become stuck to or embedded into the continent in a process called ________________.

Principle of Isostasy

10. Is the following sentence true or false? Because of accretion, deformed and thickened crust will undergo regional uplifting both during mountain building and for a long period afterward. ________________