

Foundations of Earth Science, 7e (Lutgens)

Chapter 2 Rocks: Materials of the Solid Earth

2.1 Multiple Choice

1) An igneous rock that shows a vesicular texture _____.

- A) contains many small holes, like Swiss cheese
- B) must be extrusive
- C) must be fine grained
- D) all of the above

Answer: D

Diff: 1

LO/Section: 2.2

Bloom's Taxonomy: Comprehension

2) An igneous rock that cools rapidly is likely to have _____ crystals.

- A) small
- B) medium-sized
- C) large
- D) pink

Answer: A

Diff: 1

LO/Section: 8.2

Bloom's Taxonomy: Knowledge

3)



Examine the rock sample here. Did it form at the surface or below the surface, and how do you know?

- A) It formed at the surface, because of its color (composition).
- B) It formed at the surface, because of its texture (grain size).
- C) It formed below the surface, because of its color (composition).
- D) It formed below the surface, because of its texture (grain size).

Answer: B

Diff: 2

LO/Section: 2.2

Bloom's Taxonomy: Analysis

4) Which one of the following is an igneous rock?

- A) limestone
- B) rhyolite
- C) slate
- D) quartz

Answer: B

Diff: 1

LO/Section: 2.2

Bloom's Taxonomy: Knowledge

5) Which one of the following is a sedimentary rock?

- A) limestone
- B) rhyolite
- C) slate
- D) quartz

Answer: A

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Knowledge

6) Which one of the following is a metamorphic rock?

- A) limestone
- B) rhyolite
- C) slate
- D) quartz

Answer: C

Diff: 1

LO/Section: 2.5

Bloom's Taxonomy: Knowledge

7) Rocks that contain crystals that are roughly equal in size and can be identified with the unaided eye are said to exhibit a _____ texture.

- A) fine-grained
- B) coarse-grained
- C) glassy
- D) porphyritic

Answer: B

Diff: 1

LO/Section: 2.2

Bloom's Taxonomy: Knowledge

8) Magma that might have cooled slowly to produce a diorite is instead erupted at Earth's surface. It would chill rapidly and produce a(n) _____.

- A) rhyolite
- B) andesite
- C) basalt
- D) granite

Answer: B

Diff: 2

LO/Section: 2.2

Bloom's Taxonomy: Application

9) Which igneous texture is characterized by two distinctively different crystal sizes?

- A) fine-grained
- B) coarse-grained
- C) glassy
- D) porphyritic

Answer: D

Diff: 1

LO/Section: 2.2

Bloom's Taxonomy: Knowledge

10) Granite is _____.

- A) what countertops are made of
- B) coarse-grained and dominated by quartz and feldspar crystals
- C) coarse-grained and dominated by olivine, pyroxene and plagioclase feldspar crystals
- D) fine-grained and dominated by quartz and feldspar crystals

Answer: B

Diff: 1

LO/Section: 2.2

Bloom's Taxonomy: Comprehension

11) To transform an igneous rock into a sedimentary rock, which of the following processes must take place?

- A) melting and re-cooling, followed by crystallization
- B) chemical reactions under conditions of elevated temperature or pressure
- C) weathering, transport, deposition, and lithification
- D) impact by a meteorite

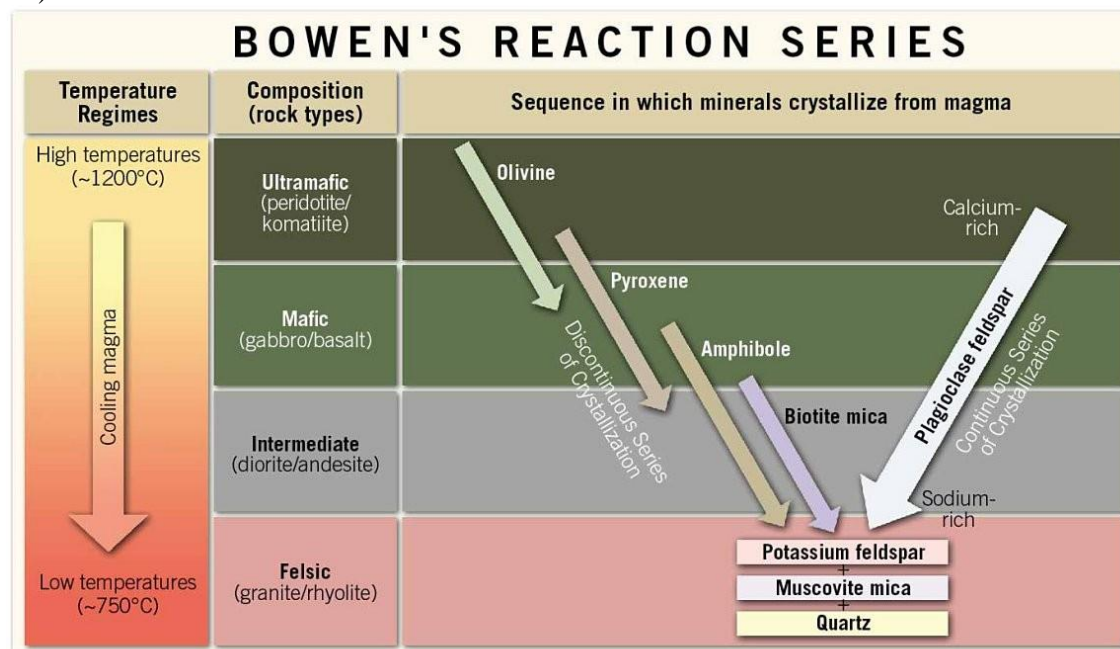
Answer: C

Diff: 1

LO/Section: 2.1

Bloom's Taxonomy: Comprehension

12)



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In general, which of the statements below best describe what happens in terms of composition as crystallization proceeds down the Bowen's reaction series (shown in the figure)?

- A) The early-formed silicates are enriched in iron and magnesium, resulting in such rocks as andesite and granite. As crystallization proceeds, the later-formed silicates are enriched in sodium, potassium, and silicon, resulting in peridotite and basalt.
- B) The early-formed carbonates are enriched in calcium and carbonate, resulting in such rocks as limestone. As crystallization proceeds, the later-formed carbonates are enriched in fossils, resulting in fossiliferous limestone and coquina.
- C) The early-formed silicates are enriched in iron and magnesium, resulting in such rocks as peridotite and basalt. As crystallization proceeds, the later-formed silicates are enriched in sodium, potassium, and silicon, resulting in andesite and granite.
- D) The early-formed silicates are enriched in sodium, potassium, and silicon, resulting in such rocks as peridotite and basalt. As crystallization proceeds, the later-formed silicates are enriched in iron and magnesium, resulting in andesite and granite.

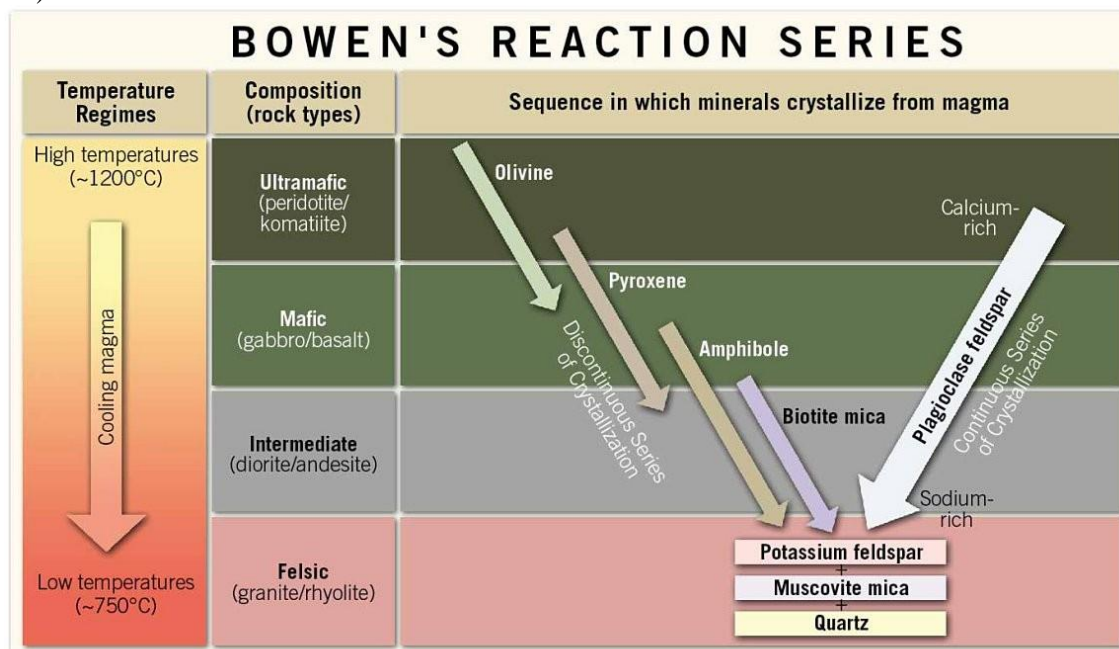
Answer: C

Diff: 1

LO/Section: 2.2

Bloom's Taxonomy: Comprehension

13)



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Consult the image that depicts Bowen's reaction series. What can be said of the temperature at which a granite crystallizes?

- A) Granite crystallizes at temperatures of about 750° C.
- B) Granite crystallizes at temperatures of about 900° C.
- C) Granite crystallizes at temperatures of about 1200° C.
- D) Nothing can be deduced from this chart about the crystallization temperature of any igneous rock.

Answer: A

Diff: 2

LO/Section: 2.2

Bloom's Taxonomy: Analysis

14) Chemical weathering would be most effective _____.

- A) in a warm, wet climate
- B) in a cold, dry climate
- C) in a warm, dry climate
- D) deep beneath a mountain range

Answer: A

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Comprehension

15) A crystal of potassium feldspar (KAlSi_3O_8) will produce a variety of weathering products after it is weathered. Which of the following is NOT a product that results from the weathering of potassium feldspar?

- A) silica
- B) potassium ions
- C) clay minerals
- D) iron oxides

Answer: D

Diff: 2

LO/Section: 2.3

Bloom's Taxonomy: Analysis

16) Three of the following statements about mechanical weathering are true. One is false. Which statement is incorrect?

- A) Mechanical weathering does not affect metamorphic rocks.
- B) Mechanical weathering produces smaller pieces.
- C) Mechanical weathering does not change the rock's mineral composition.
- D) Mechanical weathering adds to the effectiveness of chemical weathering.

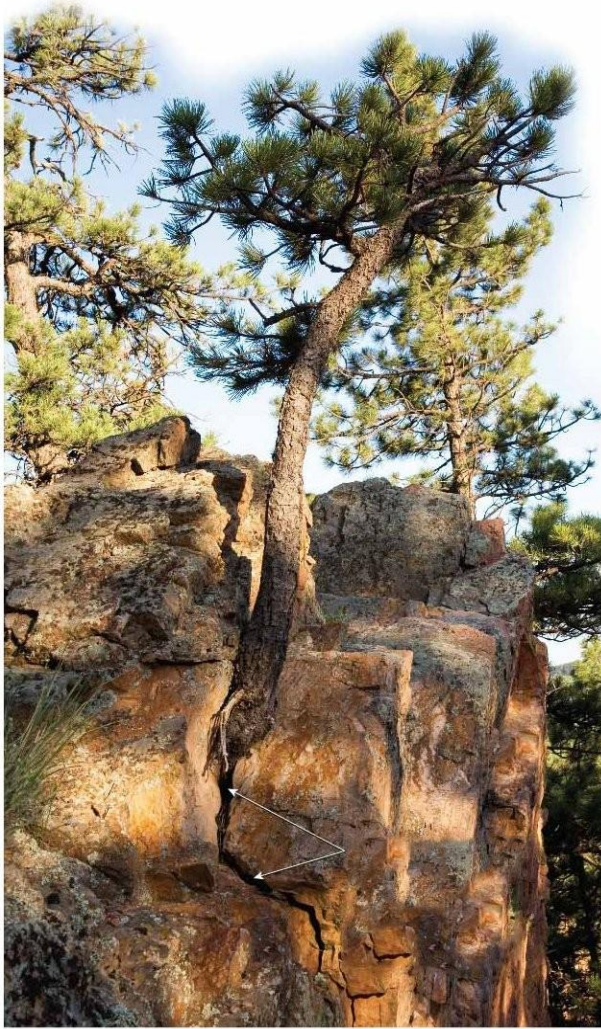
Answer: A

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Comprehension

17)



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What form of physical weathering is shown in this image?

- A) frost wedging
- B) sheeting
- C) root wedging
- D) hydrolysis

Answer: C

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Comprehension

18) Which kind of rocks may contain fossils?

- A) igneous
- B) sedimentary
- C) metamorphic
- D) minerals

Answer: B

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Knowledge

19) Most rock outcrops (about 75% of the total) are _____.

- A) igneous
- B) sedimentary
- C) metamorphic
- D) fossil-bearing

Answer: B

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Knowledge

20) Detrital sedimentary rocks are classified and named principally on the basis of _____.

- A) grain size
- B) location
- C) rock color
- D) composition

Answer: A

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Comprehension

21) Which rock type is most likely to have been deposited in a high- energy environment (such as a very turbulent stream)?

- A) conglomerate
- B) shale
- C) chert
- D) microcrystalline limestone

Answer: A

Diff: 2

LO/Section: 2.4

Bloom's Taxonomy: Application

22) The skeletal remains of plankton make up the sedimentary rock _____.

- A) flint
- B) breccia
- C) travertine
- D) chalk

Answer: D

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Knowledge

23) Which of the following rock types represents the highest grade of metamorphism?

- A) slate
- B) phyllite
- C) schist
- D) gneiss

Answer: D

Diff: 1

LO/Section: 2.5

Bloom's Taxonomy: Knowledge

24) Regional metamorphism occurs during _____.

- A) intrusion of magma
- B) mountain building
- C) sheeting of exposed plutons of granite
- D) chemical weathering of limestone in caves

Answer: B

Diff: 1

LO/Section: 2.5

Bloom's Taxonomy: Comprehension

2.2 True-False

1)



This photo shows a conglomerate.

Answer: FALSE

Diff: 2

LO/Section: 2.4

Bloom's Taxonomy: Application

2) All varieties of limestone are dominated by the mineral calcite.

Answer: TRUE

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Comprehension

3) Frying an egg is a non-geological example of contact metamorphism.

Answer: TRUE

Diff: 2

LO/Section: 2.5

Bloom's Taxonomy: Analysis

4) In order to metamorphose, metamorphic rocks must melt.

Answer: FALSE

Diff: 1

LO/Section: 2.5

Bloom's Taxonomy: Comprehension

5) Confining pressure produces foliated metamorphic rocks.

Answer: FALSE

Diff: 2

LO/Section: 2.5

Bloom's Taxonomy: Application

6) The parent rock of marble is sandstone.

Answer: FALSE

Diff: 1

LO/Section: 2.5

Bloom's Taxonomy: Comprehension

7) Because of its rock cleavage, slate makes a better roofing material than rock gypsum.

Answer: TRUE

Diff: 2

LO/Section: 2.5

Bloom's Taxonomy: Analysis

8) Coal is a sedimentary rock that is made of organic matter.

Answer: TRUE

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Comprehension

9) Mud cracks and ripple marks are common features of igneous rocks.

Answer: FALSE

Diff: 3

LO/Section: 2.4, 2.2

Bloom's Taxonomy: Synthesis

10) Compaction and cementation are the most common forms of lithification.

Answer: TRUE

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Comprehension

11) All metamorphic rocks began as other rocks ("parent rocks") that were then subjected to elevated temperatures or pressures.

Answer: TRUE

Diff: 1

LO/Section: 2.5

Bloom's Taxonomy: Comprehension

12) A large proportion of feldspar sets arkose apart from regular sandstone.

Answer: TRUE

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Knowledge

13) Given the right conditions any kind of rock can be transformed into any other kind of rock.

Answer: TRUE

Diff: 1

LO/Section: 2.1

Bloom's Taxonomy: Comprehension

14) Rusting is an example of mechanical weathering.

Answer: FALSE

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Knowledge

15) Slate is a common nonfoliated metamorphic rock.

Answer: FALSE

Diff: 1

LO/Section: 2.5

Bloom's Taxonomy: Comprehension

2.3 Fill in the Blank

1) Granite and gabbro have a similar _____.

Answer: texture

Diff: 1

LO/Section: 2.2

Bloom's Taxonomy: Comprehension

2) Obsidian is characterized by its _____ texture.

Answer: glassy

Diff: 1

LO/Section: 2.2

Bloom's Taxonomy: Knowledge

3) _____ is formed when carbon dioxide dissolves in rainwater, and this mildly reactive substance aids chemical weathering.

Answer: carbonic acid

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Knowledge

4) Before it can be sedimentary rock, sediment must be produced (weathered from pre-existing rocks), transported, deposited, and _____.

Answer: lithified

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Comprehension

5) In contact metamorphism, _____ is the dominant agent of change.

Answer: heat

Diff: 1

LO/Section: 2.5

Bloom's Taxonomy: Knowledge

6) The rock _____ is a description of how one rock may be transformed into another kind of rock through various internal and external processes.

Answer: cycle

Diff: 1

LO/Section: 2.1

Bloom's Taxonomy: Knowledge

7) A detrital sedimentary rock dominated by sand is a(n) _____.

Answer: sandstone

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Knowledge

8) Chemical sedimentary rocks form when _____ in solution precipitate out mineral matter.

Answer: ions

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Comprehension

9) Layers in sedimentary rocks are called _____.

Answer: beds

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Comprehension

10) The difference between a breccia and a conglomerate is _____.

Answer: conglomerates have rounded grains; breccias have angular grains

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Comprehension

11) Rock salt and rock gypsum are examples of _____ sedimentary rocks.

Answer: chemical

Diff: 1

LO/Section: 2.4

Bloom's Taxonomy: Knowledge

12) When a granite pluton (formed deep underground) is uplifted and exposed at the surface, it may undergo sheeting to form a(n) _____.

Answer: exfoliation dome

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Knowledge

13) Heat, confining pressure, differential stress, and _____ are four agents that drive metamorphic reactions.

Answer: chemically active fluids

Diff: 1

LO/Section: 2.5

Bloom's Taxonomy: Knowledge

14) Confining pressure results from _____ of rocks.

Answer: burial

Diff: 1

LO/Section: 2.5

Bloom's Taxonomy: Comprehension

15) The reason we see so much mud and sand along the shore of the land is that clay minerals and quartz are _____ at Earth's surface.

Answer: stable

Diff: 2

LO/Section: 2.3

Bloom's Taxonomy: Application

2.4 Matching

Match the items in the first column with the correct descriptions in the second column.

- A) Reactions that take place, often facilitated by water, to new produce products, mainly clay minerals, which are stable at Earth's surface.
- B) The reaction of a substance (often a metal ion) with oxygen. Rust is an example.
- C) The breaking of rock into smaller pieces.
- D) When water freezes, it expands in volume. Water-filled cracks can be enlarged when this new ice exerts outward pressure on the walls of the fracture.
- E) The expansion of rocks that formed under high confining pressure, once they are uplifted and exposed at Earth's surface producing fractures that are broadly curved and parallel to the land surface.
- F) Pressure that is unequal in different directions, such as results from the convergence of tectonic plates (mountain-building)
- G) A substance that forms when carbon dioxide in the air combines with water. It is an important agent of chemical weathering.
- H) Pressure that is equal in every direction, such as results from the burial of sediments

1) Differential stress

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Comprehension

2) Confining pressure

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Comprehension

3) Frost wedging

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Comprehension

4) Sheeting

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Comprehension

5) Oxidation

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Comprehension

6) Carbonic acid

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Comprehension

7) Mechanical weathering

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Comprehension

8) Chemical weathering

Diff: 1

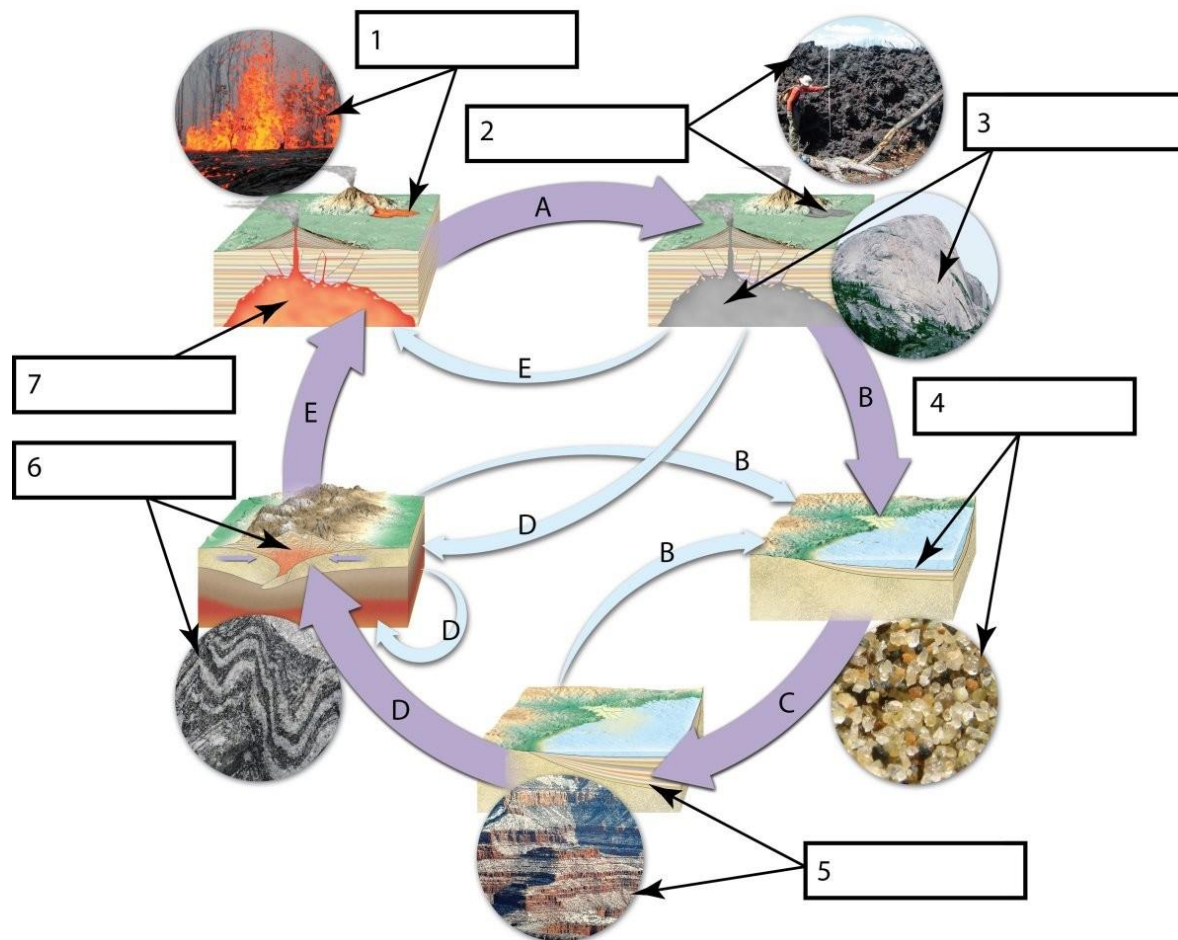
LO/Section: 2.3

Bloom's Taxonomy: Comprehension

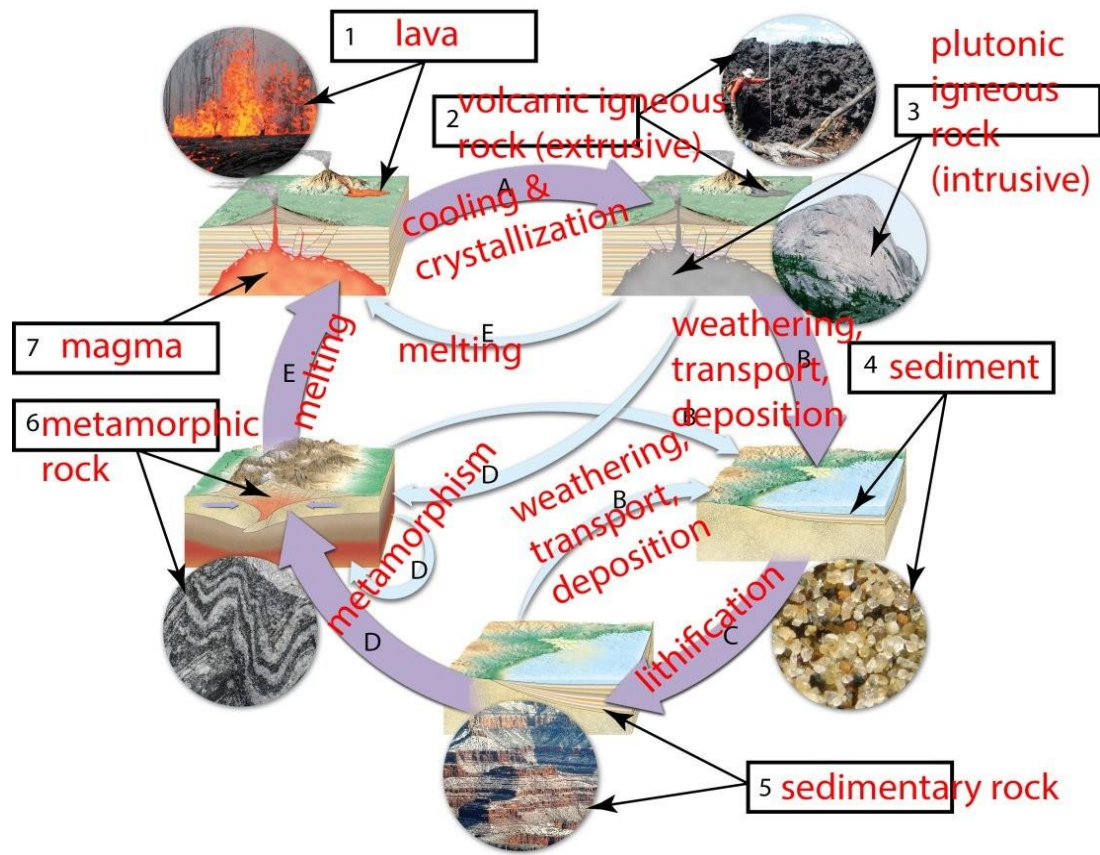
Answers: 1) F 2) H 3) D 4) E 5) B 6) G 7) C 8) A

2.5 Labeling

1) Label each process or set of processes (lettered arrows) and Earth materials (numbered boxes).



Answer:



Diff: 1

LO/Section: 2.1

Bloom's Taxonomy: Comprehension

2.6 Essay

Answer the questions in complete sentences. Be complete but concise.

1) Discuss how the following variables influence the rate of weathering: Mineral content, climate, and topography.

Answer: More stable minerals, like quartz, are more resistant to weathering. Minerals that are less stable (less at equilibrium at Earth surface conditions) are less resistant to weathering; they fall apart more rapidly. Hence a tombstone made of granite will last longer than a tombstone made of marble ... or worse, rock salt! Warmer, wetter climates encourage weathering, as water helps facilitate chemical reactions like dissolution, oxidation, and hydrolysis, and more heat means more energy to drive those reactions. Steeper slopes are more likely to shed any sediment that gets produced, meaning that physical weathering will dominate over chemical weathering. Shallower slopes tend to see less movement of the sediment that results from weathering, resulting in thick sections of "rotted" (chemically weathered) bedrock.

Diff: 1

LO/Section: 2.3

Bloom's Taxonomy: Comprehension

2)



Identify each photo with a material name. Explain the processes which would have to occur as each material is transformed (arrows) into other materials. Include a plausible "next step" to replace the big question mark at the end.

Answer: Pebbles, a kind of sediment, could be transformed into a conglomerate through the process of lithification. After they were generated, transported (causing them to round), and deposited, the pebbles would then either be compressed or cemented together to form the sedimentary rock conglomerate. This conglomerate could be induced to melt with application of sufficient heat, rendering it into magma. That magma could cool and crystallize, producing the igneous rock granite. In terms of what happens next, this granite might experience differential stress and be metamorphosed in a mountain-building event to produce a gneiss. (Answers for this last part will vary.)

Diff: 3

LO/Section: 2.1, 2.2, 2.3, 2.4

Bloom's Taxonomy: Synthesis

3)



How are the two main categories of weathering represented in this image that shows human-made objects?

Answer: The broken glass bottles provide an example of mechanical weathering: to make them, a single glass bottle would have to be shattered into numerous shards of glass. Though many new pieces of glass result, the substance itself (glass) has not been transformed into anything new. In contrast, the rusty cans provide an example of chemical weathering: to make them, an initial can would have to react with oxygen in the atmosphere (an oxidation reaction facilitated by water) and a new substance (rust) would be produced at the expense of the material that composed the original cans.

Diff: 3

LO/Section: 2.3

Bloom's Taxonomy: Synthesis

2.7 Critical Thinking

1) What is the source of energy that transforms igneous rocks into sedimentary rocks? What is the source of energy that transforms sedimentary rocks into metamorphic rocks? What is the source of energy that transforms metamorphic rocks into igneous rocks? Are these sources of energy internal or external? Explain.

Answer: Sedimentary result from external processes including weathering, transport, and deposition. The energy to break down and move sediment comes ultimately from the Sun. To get rocks to a place where they can be weathered, energy from plate tectonics must also be involved. Igneous rock are certainly related to internal heat and plate tectonics; Metamorphic are also more internal-process related. A sedimentary rock that is going to be transformed into an igneous rock by melting will most likely first metamorphose as it warms up. So, metamorphic and igneous rocks form as a result of Earth's internal energy, the same energy that drives plate tectonics. The surface processes that generate, move, and dump sediments are ultimately driven by solar energy.

Diff: 3

LO/Section: 2.1, 2.2, 2.3, 2.4, 2.5

Bloom's Taxonomy: Synthesis

2) Why would intrusive rocks chemically weather more quickly than extrusive rocks? Why would mafic rocks chemically weather more easily than felsic rocks?

Answer: There are several reasons that intrusive rocks would chemically weather more quickly than extrusive rocks. The place they form is the first reason: by definition, extrusive igneous rocks form at Earth's surface, which is also where weathering happens. For intrusive igneous rocks to experience weathering at Earth's surface, they must first go through an additional step: uplift sufficient to cause exposure. Second is the issue of grain size. Minerals weather from the outside, in. Smaller mineral grains have a greater amount of surface per unit of volume, while relatively coarse crystals in plutons have less reactive surface area. Basaltic (mafic) rocks have a greater proportion of dark silicate minerals, which are enriched in the elements iron and magnesium, both of which are susceptible to oxidation. Felsic rocks have a higher proportion of quartz, which is stable at Earth surface conditions.

Diff: 3

LO/Section: 2.2, 2.3

Bloom's Taxonomy: Synthesis

3) Consider the history of a single crystal of quartz. Describe how could this quartz grain could (a) form in a granite, (b) become incorporated into a sandstone, and (c) be transformed into a quartzite? Explain the processes which act on the quartz crystal and the transformations it experiences. Detail the processes which would take place along each portion of this journey.

Answer: The quartz crystal would originally form from magma, cooling deep in Earth's interior. Because it's part of an intrusion of magma, it cools slowly, so there's plenty of time to grow a nice coarse quartz crystal. It forms last among the minerals in the crystallizing magma, as predicted in Bowen's reaction series. Because of the felsic composition and the coarse grain size, the rock that this quartz (mineral) grain is part of would be referred to as a granite. Once solidified, time goes by, and the granite is uplifted towards the surface. When it gets to the surface, it is attacked by chemical and mechanical weathering. Sheetting occurs, and carbonic acid in rainwater helps to break down the quartz's neighboring feldspars. The few dark silicate minerals in the granite are oxidized. One day, in a big storm, the quartz crystal breaks free and is tumbled down a small stream along with a bunch of clay minerals. The small stream feeds into a big river, and the quartz grain eventually is transported to the ocean. There, it is deposited on a beach full of similar sand-sized grains of quartz. Over geologic time, these sand layers are buried and subjected to confining pressure, and they become lithified to form a sandstone. A new intrusion of magma occurs nearby, and the sandstone is "cooked" by its heat. The small quartz grains recrystallize, fusing together and forming large, equidimensional grains that are randomly oriented. It is now a quartzite, a metamorphic rock.

Diff: 3

LO/Section: 2.1, 2.2, 2.3, 2.4, 2.5

Bloom's Taxonomy: Synthesis