LAB STATION A: Minerals

Directions: Enter the specimen names on the lines provided on the Participant Response Sheet. Only the names of specimens actually included at this station will be accepted.

1. Which abundant, nearly pure silicon dioxide specimen occurs in most igneous and practically all metamorphic and sedimentary rocks?
2. Which three specimens exhibit cleavage with weak bonds in only one direction?
3. Which specimen is classified as an evaporite due to its having been formed by the evaporation of saline water within partially enclosed basins?
4. Which mineral is able to overpower and displace surrounding solid material during its formation so that it almost always develops its characteristic crystal faces?
5. Which specimen, often associated with the minerals sphalerite and galena, is the main source of copper?
6. Which mineral is a major source of zinc?
7. Which mineral's streak is always reddish brown in color in spite of its actual color being brown, red or silver?
8. Which mineral has a specific gravity of 19.3?
9. Which is the most common mineral found in Earth's crust?
10. Which specimen is not a crystalline solid and is, instead, classified as a mineraloid?
11. Which mineral is the primary source of lead?
12. Which mineral consists of a basic silicate of iron and aluminum in prismatic orthorhombic crystals often twinned so as to resemble a cross?
13. Which specimen, represented by its more rare octahedral crystal form at this station, occurs naturally in nearly every color of the spectrum?
14. Which specimen is a form of microcline named for a South American rainforest where it is nowhere to be found?
15. Which specimen's optical effect is created by individual fibers acting as fiber-optic cables, transmitting light from one surface to the other?
16. Which mineral has a pleasant blue color, usually includes white veins or streaking, and is commonly used as a carving stone?
17. Which pink and red specimen often has black manganese oxide veins running through it, giving it the distinct appearance of pink with black crisscrossing lines?
18. Identify the two associated minerals embedded within the same sample specimen.
19. Which mineral's crystal habits include saddle shaped rhombohedral twins and simple rhombs, some with slightly curved faces?
20. Which mineral has several varieties, including the emerald specimen at this station?

LAB STATION B: Igneous Rocks

Part A: Record the specimen number indicating your choice on the Participant Response Sheet.

1. Which specimen formed as large amounts of gas escaped the lava ejected into the atmosphere?
2. Which specimen formed as gas bubbles escaped the top layers of lava flows?
3. Which specimen formed as magma, in which crystals had already formed while deep beneath the Earth's surface, was suddenly erupted onto the surface?
4. Which two igneous specimens are composed primarily of feldspar and quartz?
5. Which specimen forms many of the world's volcanic islands, including the islands of Hawaii and Iceland?
6. Which specimen is the most common extrusive igneous rock?
7. Which specimen frequently forms the core of eroded mountains including Pikes Peak, Mount Rushmore, the White Mountains, Stone Mountain and Yosemite National Park?
8. Which two igneous specimens may be referred to as intermediate – midway in color between felsic and mafic?
9. Which two igneous specimens have a felsic composition?
10. Which two igneous specimens have a mafic composition?
11. Which specimen formed in open cavities permitting crystal growth without much interference from other crystals?
12. Which three specimens are amorphous, that is, they solidified with no fixed or regular internal atomic structure?

Part B: Extrusive vs. Intrusive Igneous Rocks

Directions: Enter "**I**" if the statement refers to intrusive igneous rocks only; "**E**" if the statement refers to extrusive igneous rocks only, or "**B**" if the statement refers to both intrusive and extrusive igneous rocks.

13. Cooled and solidified at a considerable depth
14. Visual appearance reveals interlocking crystals forming the rock mass
15. Silica is the most abundant component
16. Named and identified on the basis of composition and texture
17. Characterized by fine-grained textures
18. Formed at or above the surface of the planet
19. Formed from the crystallization of minerals
20. Characterized by large crystal sizes
21. Cooling and hardening is typically quite slow
22. Cooling and hardening is typically quite rapid
23. Contain feldspar minerals
24. Surface feels relatively smooth
25. Surface feels relatively rough
26. May become transformed into sedimentary rocks when exposed to the Earth's surface

LAB STATION C: Sedimentary Rocks

Directions: Record the specimen number on the Participant Response Sheet.

1. Which specimen resulted from the lithification of angular rock fragments transported a relatively short distance from its source? The angular rock fragments may have been deposited, undergone compaction, and finally cemented together by precipitated minerals, such as quartz. This specimen may have been created by the cementation of fractured rock in situ, without having undergone the processes of erosion and deposition.
2. Which specimen is composed of rounded clasts within a fine-grained matrix? A fast moving river transported and deposited these clasts along with finer sediments.
3. Which specimen is generally formed from the weathering of feldspar-rich igneous or metamorphic rocks composed primarily of quartz and feldspar? The sediments were deposited rapidly and/or in a cold or arid environment such that the feldspar did not undergo significant chemical weathering and decomposition.
4. Which specimen formed by a process of rapid precipitation of calcium carbonate, often at the mouth of a hot spring or in a limestone cave?
5. Which specimen resulted from extreme weathering and sorting of sediments until everything that could be removed had been removed? Complete chemical weathering was required to remove all feldspars and lithics. Final removal of clay occurred in high energy environments, typically a beach environment.
6. Which specimen is quite likely of secondary origin due to recrystallization of limestone by substitution of magnesium atoms for calcium atoms within the crystal structure?
7. Which specimen is a poorly sorted rock, packed full of the skeletons of varied sizes, jumbled and cemented together?
8. Which specimen is a biochemical rock composed of microscopic skeletons of single celled organisms commonly referred to as coccoliths? These surface-dwelling organisms, upon death, settled and accumulated at shadowy depths?
9. Which specimen is a fine-grained, laminated rock composed of lithified clay, commonly formed in basins, shelves, deltas, meandering rivers, and flood plains?
10. Which specimen, with a fixed 85% to 95% carbon content, underwent structural deformation under very low grade metamorphic conditions?
11. Which specimen, formed in a warm, supersaturated, shallow, highly agitated marine environment, is commonly associated with zones of high tidal activity in a sub-tidal or lower intertidal environment?
12. Which specimen is composed of a fixed carbon with varying amounts of sulfur and other elements resulting from plant remains being buried under anaerobic conditions for an extended period of time?

LAB STATION D: Metamorphic Rocks

1. Describe the only location that provides the intense and extreme heat and pressure required to form metamorphic rocks.

2. Classify each phrase as being true for contact metamorphism (record as "**C**"), regional metamorphism (record as "**R**") or both contact and regional metamorphism (record as "**B**").

a. occurs adjacent to igneous intrusions

b. minerals crystallize

c. large crystals are formed

d. results in folds or curves

e. mineral crystals are rearranged

f. usually results in foliated metamorphic rocks

g. may result from tectonic forces resulting in compressional stresses

3. a. Arrange the metamorphic rock specimens numbered 30, 20, 27 and 2 in order of progressive metamorphism. Record specimen numbers only.

b. Identify the two conditions that drive this sequence of metamorphism.

4. Pressure within a metamorphic environment correlates with (record the letter).

a. composition of the parent rock
b. speed of transport
c. depth
d. fluids present

5. Which class of rocks results when pressure and temperatures exceed the upper limits of metamorphism? (record the letter)

a. igneous
b. sedimentary

Directions, 6 - 12: Record the specimen number(s) on the Participant Response Sheet.

6. Which two specimens are described as non-foliated?

7. Which specimen has a tendency to split into planar sheets?

8. Which coarse-grained specimen segregated into layers as it was deformed at high temperatures?

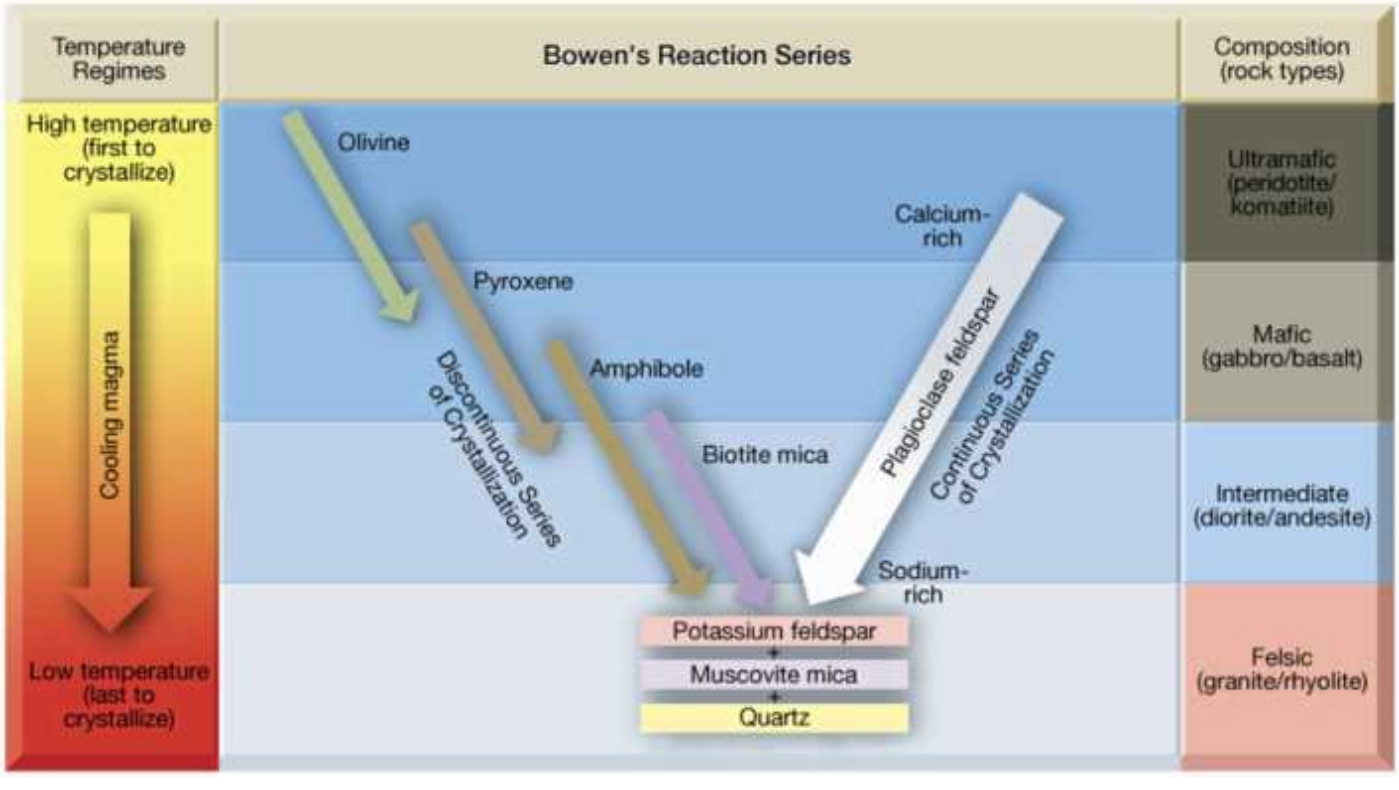
9. Which four specimens were derived from regional metamorphism of shale?

10. Which specimen was derived from regional metamorphism of high-silica igneous rocks and muddy sandstones?

11. Which specimen, composed of finely to coarsely crystalline calcite or dolomite, was formed during metamorphism of limestone or dolomite rock?

12. Which specimen, composed of fine to coarse crystalline quartz, was derived from metamorphism of quartz sandstone and chert?

LAB STATION E: Bowen's Reaction Series



1. Which is the first mineral to crystallize from the very high temperatures as magma first starts to cool?
2. Which is the last mineral to form from the last remaining melt of high silica content?
3. (T-F) Bowen's reaction series indicates that minerals with the highest melting temperatures crystallize from a cooling magma before those with lower melting points.
4. (T-F) Bowen's reaction series explains the origin of magmas.
5. (T-F) Bowen's reaction series indicates that ferromagnesian minerals in magma crystallize in the sequence shown in the discontinuous branch.
6. (T-F) Bowen's reaction series offers an explanation for the differentiation of silicic and mafic minerals in magma.
7. Which is the most stable of the minerals in the Discontinuous Reaction Series?

Directions, 8 – 14: Record the specimen letter indicating your choice on the Response Sheet.

8. Which bonding occurs at the highest temperatures within the Discontinuous Branch?
   a. ionic b. covalent
9. Which reaction series follows a repetitive sequence of stable to unstable pattern, not permitting simultaneous formation of similar minerals?
   a. continuous b. discontinuous
10. Which reaction series follows a gradual transitional pattern of mineral formation thus permitting combinations of minerals to form and exist as the magma cools?
    a. continuous b. discontinuous
11. Which list the sequence of ferromagnesian silicate minerals crystallizing from a cooling magma?
    a. amphibole, olivine, biotite, pyroxene
    b. biotite, amphibole, pyroxene, olivine
    c. olivine, pyroxene, amphibole, biotite
    d. pyroxene, olivine, amphibole, biotite
12. Of the following, which rock type is most likely to contain calcium-rich feldspar?
    a. basalt b. granite c. pumice d. rhyolite
13. Of the following paired minerals, which are characteristic of lower crystallization temperatures and absent in basalt and gabbro?
    a. pyroxene and olivine
    b. quartz and pyroxene
    c. biotite and olivine
    d. quartz and muscovite
14. Bowen's Reaction Series illustrates the relationship between:
    a. viscosity, volatile content and temperature.
    b. mineral composition, viscosity and temperature.
    c. chemical composition, temperature and mineral structure.
    d. pressure, viscosity, silica content and temperature.

LAB STATION F: Crystal Systems

Part I: Any line passing through the center of a crystal around which the crystal may be rotated is an **AXIS OF SYMMETRY**.

1. Identify the cubic-shaped mineral specimen at this station.

2. Imagine an axis, or line, connecting the center of one face of a cube with the center of the face directly opposite the first. Rotate the crystal at this station around a single axis for one complete turn. What is the total number of similar-appearing sides, each referred to as a "fold," displayed during a single rotation of the crystal? This axis, therefore, is referred to as a "____-fold axis of symmetry."

3. A cube may also be rotated around an axis of symmetry connecting opposite corners of a cube. How many corner-to-corner axes does a cube-shaped crystal possess?

4. A single rotation around one of these axes would be properly called a _____-_____ axis of symmetry.

5. Identify the two hexagonal-shaped minerals at this station?

6. A hexagonally-shaped crystal has six sides, or folds, plus an additional seventh that may be of any length. What phrase describes the axis of symmetry traveling lengthwise through these crystals?

7. A hexagonally-shaped crystal also has six additional axes of symmetry (three of which are from side-to-side and three of which are from edge-to-edge). What phrase describes these axes of symmetry?

8. Identify the rhombohedral-shaped crystal at this station.

9. How many two-fold axes of symmetry does the rhombohedral-shaped crystal possess?

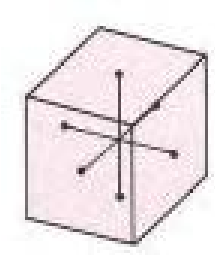
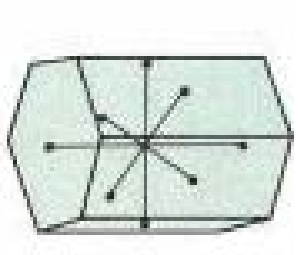
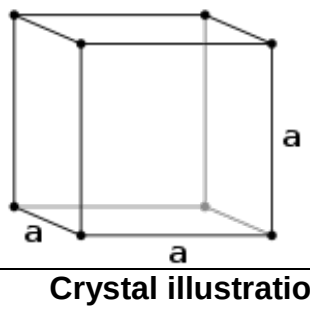
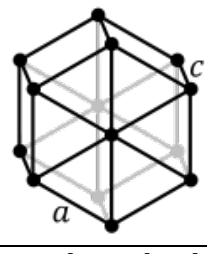
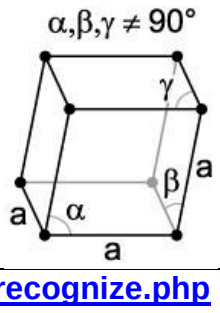
Part II: **Planes of symmetry** divide crystals into equal parts (mirror images) that correspond point for point, angle for angle, and face for face. They may divide a crystal from side-to-side and edge-to-edge.

10. How many "side-to-side" planes of symmetry are contained within a single cube?

11. How many "edge-to-edge" planes of symmetry are contained within a single cube?

12. How many total planes of symmetry are contained within a single cube?

13. How many total planes of symmetry does the hexagonal-shaped specimen contain?

ISOMETRIC	HEXAGONAL	RHOMBOHEDRAL
		
		

Crystal illustrations (top row) from www.mineralogicalassociation.ca/young/recognize.php

Note: Due to the complexity of the rhombohedral-shaped crystal, identifying its planes of symmetry is beyond the scope of this exam.

Rocks & Minerals Exam **Answer Key**

LAB STATION A: Minerals

1 quartz (also accept quartz crystal)

2 lepidolite, muscovite, biotite (any order)

3 halite

4 almandine garnet (also accept either almandine or garnet)

5 chalcopyrite (or bornite)

6 sphalerite

7 hematite

8 gold

9 feldspar

10 opal

11 galena

12 staurolite

13 fluorite

14 amazonite

15 ulexite

16 sodalite

17 rhodonite

18 azurite and malachite (either order)

19 dolomite

20 beryl

Tie-Breakers:

1st – Most stations with zero errors

2nd – Most stations with only 1-3 errors

3rd – Highest total number of tie-breakers* answered correctly

Rocks & Minerals Exam **Answer Key**

LAB STATION B: Igneous Rocks

Part A:

1 11

2 7

3 26

4 19 / 15 any order

5 13

6 13

7 19

8 21 / 26 any order

9 19 / 15 any order

10 28 / 13 any order

11 25

12 6 / 11 / 7 any order

Part B:

13. I

14. I

15. B

16. B

17. E

18. E

19. B

20. I

21. I

22. E

23. B

24. E

25. I

26. B

Rocks & Minerals Exam **Answer Key**

LAB STATION C: Sedimentary Rocks

1	1
2	23
3	24
4	17
5	10
6	4
7	14
8	18
9	9
10	29
11	22
12	12

Rocks & Minerals **Answer Key**

LAB STATION D: Metamorphic Rocks

1. Deep within the Earth (or similar response)

2. a c

   b b

   c b

   d r

   e b

   f r

   g r

3. a. 27, 2, 30, 20 must be recorded in this sequential order

   b. heat and pressure may be reversed

4 c

5 a

6 5, 8 may be reversed

7 27

8 20

9 2, 16, 27, 30 any order

10 20

11 5

12 8

Rocks & Minerals **Answer Key**

LAB STATION E: Bowen's Reaction Series

1 olivine

2 quartz

3 true

4 false

5 true

6 true

7 biotite (or biotite mica)

8 a

9 b

10 a

11 c

12 a

13 d

14 c

Rocks & Minerals Exam **Answer Key**

LAB STATION F: Crystal Systems

Note to grader: Acceptable alternate responses are provided in parentheses.

Part I

1 pyrite (or iron pyrite)

2 four (or 4)

3 three (or 3)

4 three-fold (or 3-fold)

5 corundum and apatite

6 six-fold (or 6-fold)

7 two-fold (or 2-fold)

8 calcite

9 3

Part II

10 3

11 6

12 9

13 7