

Please read the questions carefully. Use pencil only. Write as neatly as you can; erase stray marks. It is better to guess than to leave blank. Ask if you have questions. Good luck! ☺

Part A - Multiple Choice - Neatly circle the letter corresponding to the best answer.

1. **Which of the following statements is a scientific hypothesis?**
 - a. Olivine is made of magnesium and iron.
 - b. The dinosaur extinction was caused by a meteorite impact.
 - c. Salt dissolves in water.
 - d. Feldspar is found in the Earth's crust.
 - e. Mercury is the closest planet to the sun.

2. **Alfred Wegener presented all of the following as evidence in support of continental drift except:**
 - a. the alignment of mountain ranges and rock units on different continents
 - b. the similarity of plant and animal fossils on different continents
 - c. the jigsaw-puzzle fit of the continents
 - d. the age of the ocean floor
 - e. the distribution of glacial deposits on different continents

3. **Which of the following layers of the Earth is made of solid iron and nickel?**
 - a. lithosphere
 - b. mantle
 - c. inner core
 - d. outer core
 - e. crust

4. **Tectonic plates move at approximately:**
 - a. 0.1-1 millimeters a year
 - b. 1-10 centimeters a year
 - c. 10-15 meters a year
 - d. 20-30 kilometers a year
 - e. Geologists do not know how fast plates move

5. **At which type of plate boundary would you find deep earthquakes?**
 - a. ocean-continent convergent
 - b. continent-continent convergent
 - c. divergent
 - d. transform
 - e. all type of plate boundaries

6. **Recently, geologists studying igneous rocks from a cinder cone in Goldendale, Washington discovered a xenolith in the rocks. What is it that they discovered?**
 - a. gas bubbles trapped in the rock
 - b. a cast of a tree, fossilized by the flowing lava
 - c. a mineral that only forms in felsic volcanic rocks
 - d. a piece of the Earth's mantle that was carried to the surface by magma
 - e. fine crystals imbedded in a matrix of coarse crystals

7. **Continental lithosphere always (~99% of the time) subducts beneath oceanic lithosphere.**
- True
 - False
8. _____ combine to form _____, which combine to form _____.
- minerals ... rocks ... elements
 - elements ... minerals ... rocks
 - elements ... rocks ... minerals
 - rocks ... minerals ... elements
 - rocks ... elements ... minerals
9. **Which of the following automobiles is named after a charged particle (an atom that no longer has an equal number of electrons and protons)?**
- Honda Element
 - Dodge Neon
 - Mini Cooper
 - Mitsubishi Diamante
 - Saturn Ion
10. **A recent geologic study used two isotopes of oxygen (^{16}O and ^{18}O) found in ocean sediments to determine the temperature of ancient oceans. These two isotopes of oxygen are different from each other in that they have different numbers of:**
- protons
 - electrons
 - positrons
 - neutrons
 - klingsons
11. **Which of the following pairs of elements make up the vast majority (%) of Earth's crust?**
- oxygen & calcium
 - iron & nickel
 - carbon & oxygen
 - aluminum & uranium
 - silicon & oxygen
12. **The minerals calcite and aragonite have the same chemical formula (CaCO_3) but different crystalline structures. Therefore they are:**
- mineraloids
 - fluorescent
 - polymorphs
 - ionic substitutions
 - pyroclastics
13. **The silicon-oxygen tetrahedron has _____ silicon atoms and _____ oxygen atoms.**
- 2 ... 2
 - 2 ... 4
 - 4 ... 1
 - 1 ... 4
 - 4 ... 2

14. **Which of the following is not a valid arrangement of silicon-oxygen tetrahedra?**
- sheet
 - spiral
 - framework
 - independent tetrahedra
 - double chain
15. **Magmas are classified into three compositional ranges based mainly on:**
- silica content
 - mafic content
 - gas content
 - iron content
 - water content
16. **The following rock types form from magmas with the same general composition:**
- gabbro & rhyolite
 - rhyolite & granite
 - granite & gabbro
 - rhyolite & basalt
 - granite & basalt
17. **Which of the following is most important in determining the texture of an igneous rock?**
- the plate-tectonic setting
 - the rate at which the magma cooled
 - the source of the magma
 - the size of the rock
 - the composition of the magma
18. **According to Bowen's Reaction Series, which of the following minerals is most likely to form the phenocrysts (large mineral crystals) in a porphyritic mafic rock?**
- olivine
 - quartz
 - biotite mica
 - potassium feldspar (orthoclase)
 - muscovite mica
19. **According to Bowen's Reaction Series, which of the following pairs of minerals would you not find together in the same igneous rock?**
- amphibole (hornblende) & biotite mica
 - olivine & calcium plagioclase
 - quartz & muscovite mica
 - quartz & olivine
 - pyroxene & calcium plagioclase
20. **When mafic lava sheets solidify on land, they may "fracture" as they cool and form:**
- vesicles
 - stratovolcanoes
 - lava tubes
 - columnar joints
 - pillow lavas

21. **The largest plutons (sometimes 100s of miles across) are discordant and are called ____.**
- laccoliths
 - sills
 - diatremes
 - batholiths
 - maria
22. **Explosive volcanic eruptions typically erupt lava that has a:**
- high viscosity and low gas content
 - high viscosity and variable gas content
 - high viscosity and high gas content
 - low viscosity and high gas content
 - low viscosity and low gas content
23. **Adding water to a rock ____ its melting temperature.**
- lowers
 - raises
 - does not affect
24. **Mt. Baker, a volcano in northern Washington, is in many ways a typical subduction-zone volcano. Which of the following features could be produced by an eruption of Mt. Baker?**
- pillow structures
 - lava tubes
 - tephra
 - shield volcanoes
 - scoria
25. **When you look up in the sky at the full moon you see large dark regions called maria. Astronauts have brought back samples showing that these rocks are mafic, fine-grained, igneous rocks. Based on this description, these rocks would be called:**
- granite
 - andesite
 - gabbro
 - tuff
 - basalt

Part B - Mixed Formats - Neatly provide the best answer to each question.

26. Complete the table below with information related to the 3 different ways in which two tectonic plates can interact. Carefully circle the ONE best answer for each cell in the table:

	The plates' motion relative to each other	What happens to oceanic lithosphere here?	An example of this type of margin
CONVERGENT MARGIN	Apart <i>or</i> Together <i>or</i> Past	Formed here <i>or</i> May be destroyed here <i>or</i> Neither	San Andreas fault <i>or</i> A mid-ocean ridge <i>or</i> A subduction zone
DIVERGENT MARGIN	Apart <i>or</i> Together <i>or</i> Past	Formed here <i>or</i> May be destroyed here <i>or</i> Neither	San Andreas fault <i>or</i> A mid-ocean ridge <i>or</i> A subduction zone
TRANSFORM MARGIN	Apart <i>or</i> Together <i>or</i> Past	Formed here <i>or</i> May be destroyed here <i>or</i> Neither	San Andreas fault <i>or</i> A mid-ocean ridge <i>or</i> A subduction zone

27. Let's consider some green gemstones and minerals. Write each mineral's "mineral family" name (oxide, silicate, etc) in the space provided.

[Al = aluminum, Be = Beryllium, C = carbon, Ca = calcium, Cu = copper, Fe = iron, Mg = magnesium, O = oxygen, S = sulfur, Si = silicon, Zn = zinc]

Green Diamond (C) is a(n) _____ mineral.

Malachite (Cu_2CO_3) is a(n) _____ mineral.

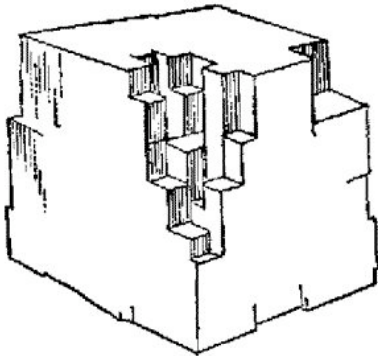
Peridot ($(\text{Mg,Fe})_2\text{SiO}_4$) is a(n) _____ mineral.

"Cat's Eye" (BeAl_2O_4) is a(n) _____ mineral.

Sphalerite (ZnS) is a(n) _____ mineral.

Antlerite (Cu_3SO_4) is a(n) _____ mineral.

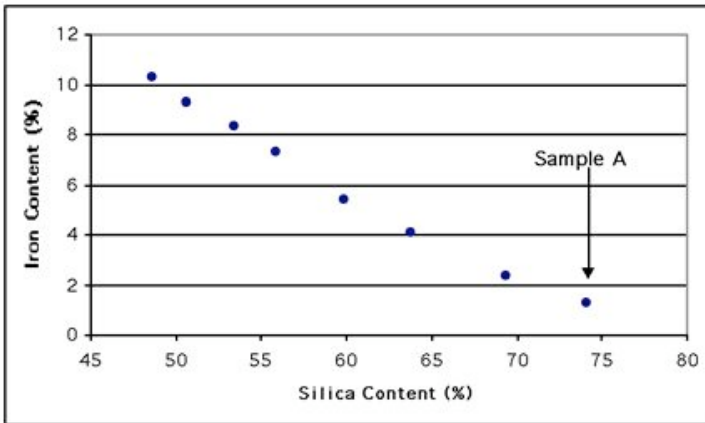
28. **The diagram below illustrates the cleavage planes of the mineral galena. This mineral can best be described as having:**



- a. 1 cleavage plane
- b. 2 cleavage planes at 90°
- c. 2 cleavage planes, not at 90°
- d. 3 cleavage planes at 90°
- e. 3 cleavage planes, not at 90°
- f. 4 cleavage planes at 90°
- g. 4 cleavage planes, not at 90°
- h. 6 cleavage planes at 90°
- i. 6 cleavage planes, not at 90°

29. **Based on its chemical formula, galena belongs to the _____ mineral family.**

30. **The graph below shows that in igneous rocks:**

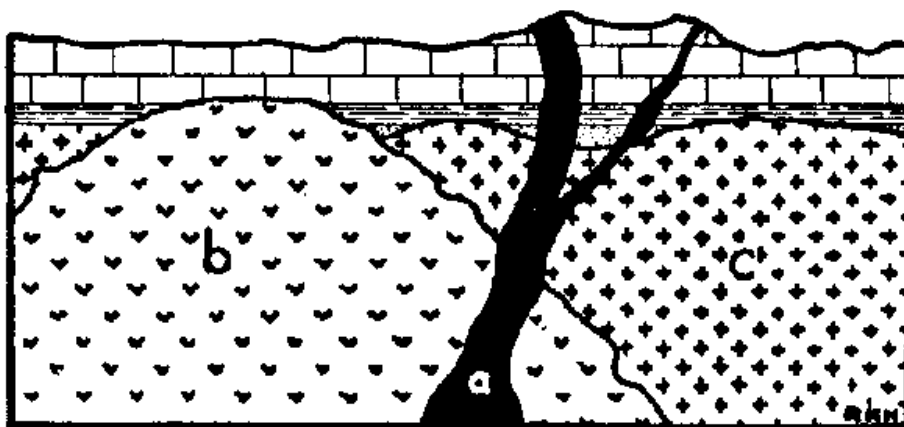


- a. as silica increases, iron increases
- b. as silica increases, iron decreases
- c. as silica increases, iron remains constant
- d. there is no relationship between silica content and iron content

31. **From the graph above, the composition of Sample A (~74% SiO₂) is:**

- a. vesicular
- b. intermediate
- c. porphyritic
- d. felsic
- e. mafic

32. **The diagram below shows a slice into Earth's crust. Unit "a" in the diagram (a gabbro represented by the black, branching unit that runs the height of the figure) is an example of:**

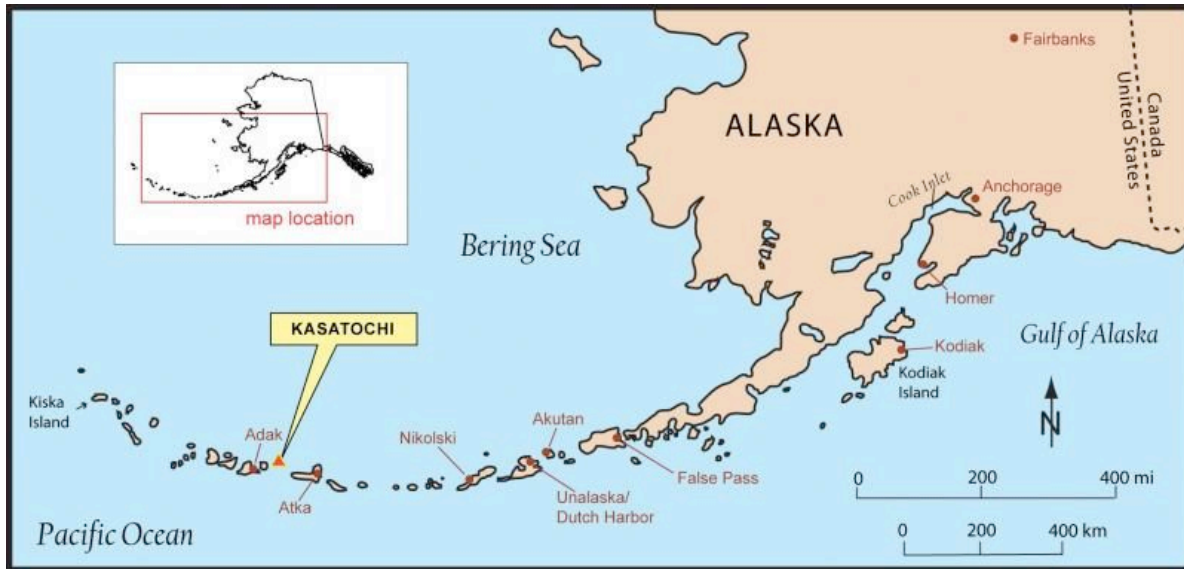


- a. a composite cone
- b. a dike
- c. a batholith
- d. a sill
- e. a columnar structure

Part C - Real-Life Application

Recently, Kasatochi Volcano in the Aleutian Islands has been erupting. Use the following information, and your knowledge of geology, to answer the questions below.

<http://www.avo.alaska.edu/image.php?id=14800> :



<http://www.usgs.gov/newsroom/article.asp?ID=1987> :

Kasatochi Volcano in Alaska's Aleutian Islands erupted explosively Aug. 7, sending an ash plume more than 35,000 feet into the air and forcing two biologists from the U.S. Fish and Wildlife Service to evacuate the island.

"Kasatochi went from a quiet volcano to an explosive eruption within 24 hours and with very little warning," said USGS volcano scientist Marianne Guffanti. "We are thankful our colleagues were able to get out before the eruption began. They were rescued just in time by a local fishing boat."

Kasatochi is the third volcano to erupt in the Aleutian Islands in three weeks. Okmok Volcano erupted unexpectedly and explosively on July 12, followed by Cleveland Volcano, 100 miles away, on July 21. Both volcanoes sent ash plumes skyrocketing and caused commercial airline flights to be diverted or cancelled.

Scientists relied on seismic instruments on other volcano networks in the area to detect activity at Kasatochi volcano.

"Fortunately, the existing seismic networks on nearby volcanoes picked up the activity at Kasatochi volcano," said Tom Murray, scientist-in-charge of the Alaska Volcano Observatory (AVO). "They were installed with funding from the Federal Aviation Administration to reduce the hazard to aviation from volcanic ash. These networks were crucial in recognizing that this volcano had entered the first stage of a major eruption."

"Our hope is to have monitoring equipment on all volcanoes that pose the greatest threats to public safety," said Guffanti. "Satellite imagery is useful to see the big picture of what is happening and what is going into the atmosphere. But direct instrumentation, such as placing seismic monitors around a volcano, will help give an early warning and give people more time to plan for hazardous events."

Scientists are working around the clock to monitor the volcanoes and keep the public and emergency responders informed.

<http://www.avo.alaska.edu/activity/Kasatochi.php> :

Satellite images collected around 2300 UTC (1500 AKDT) on August 10 showing the sulfur dioxide gas and volcanic ash cloud from the August 7, 2008 eruption of Kasatochi volcano. Please note that area of detected volcanic ash covers a much smaller area than the sulfur dioxide gas cloud; however minor amounts of ash may be associated with the gas cloud.

AVHRR image showing split window signal for ash plume from Kasatochi. Composite image of AVHRR and located earthquakes, August 7, 2008. Satellite image from 6:34 AKDT (14:34 UTC) showing the ash plume from Kasatochi. The ash is being transported in a counterclockwise spiral that extends for about 600 miles.

<http://www.avo.alaska.edu/volcanoes/volcinfo.php?volcname=Kasatochi> :

Kasatochi Island, like Gareloi, Bogoslof, and several other volcanoes in the western Aleutian arc, represents the emergent summit of a predominantly submarine volcano. The island consists of a single, undissected cone with a central lake-filled crater about 0.75 km in diameter. A maximum height of 314 m is on the southern crater rim; elevation of the lake is less than about 60 m. Kay (1990) reports a lava dome on the northwest side of the cone at an elevation of ~150 m.

Coats (1956) referred to Kasatochi as one of a group of little-known volcanoes that appear to be stratovolcanoes composed of basaltic and andesitic flows and pyroclastics. The mean slope of the southern flank (about 18 degrees) is considerably less than the mean slope of the northern flank (about 45 degrees). This asymmetry of form may reflect a predominance of lava flows low on the southern flanks, or, it may be due to a higher rate of erosion by wave action from the north. Bathymetry indicated that Kasatochi is at the northern end of a 15-km-long, 6-km-wide submarine ridge that is normal to the trend of the Andreanof Islands. Water depths along the ridge are less than 90 m; if Kasatochi is constructed entirely on the ridge, the total height of the volcanic pile is only a little more than 400 m.

33. **Based on the descriptions, Kasatochi Volcano is erupting _____ magma.**
- mafic
 - felsic
34. **Based on the descriptions, Kasatochi Volcano is erupting magma with a relatively _____ silica content.**
- high
 - low
35. **Based on the descriptions, Kasatochi Volcano is most likely which type of volcano?**
- stratovolcano
 - flood basalt plateau
 - shield volcano
36. **Based on the descriptions, what type of plate margin exists in Alaska?**
- collisional
 - divergent
 - subduction
 - transform
37. **List 3 things that geologists could monitor that might help them predict a future eruption of Kasatochi Volcano.**
- A.
 - B.
 - C.
38. **The summit of Kasatochi is covered by snow. Based on this information, what type of hazard might this volcano produce?**

Part D - Short Essay / Long Short-Answer - Choose just * ONE * of the following questions.

39. **In the space below (in small, neat writing), please list, describe, and sketch:**

- a. Three (3) lines of evidence that Earth's interior is layered.
- b. The five (5) characteristics that define a mineral. (That is: What is a mineral?)
- c. Four (4) of the many different physical properties (or pairs of properties) of minerals, not including color and cleavage/fracture, that may be used to help identify mineral samples.
- d. Three (3) types of silicate structures; provide an example of each.
- e. Three (3) pieces of evidence that could be used to defend the theory of plate tectonics (modern concept).
- f. Three (3) of the 7 volcanic hazards from the video "Understanding Volcanic Hazards".
- g. Four (4) things you learned from the Nova program "In the Path of a Killer Volcano" (about Mount Pinatubo), that you didn't learn in the textbook, lectures, or from prior knowledge.
- h. How can rocks like basalt aid scientists in piecing together the history of Earth's magnetic field.

BONUSES

*If you have time, you may answer one or more of these bonuses
in the space below and/or on a separate sheet of paper.
Focus your energy on the rest of the test; do bonus(es) only as time permits.*

- 1) What kind of igneous rock is found as benches in the Harned-Thompson courtyard? Support your answer.
- 2) What didn't I ask about on this exam, that you expected me to ask? Pose a question and answer it (correctly). (The better the question and answer, the more extra credit...within reason.)
- 3) Write a 4-to12-line poem about something you've learned in this class. It must be scientifically accurate, and mustn't be X-rated. It does not need to rhyme (but it can if you'd like).
- 4) Discuss the properties of your favorite mineral or igneous rock. Then tell me why it's your favorite!
- 5) Explain the scientific aspects of following poem, as best you can (some of the terminology in it is stuff we haven't discussed in class).

Do not go gentle into that good arc

Adapted by Gwyneth Jones (from a poem by Dylan Thomas)

Do not go gentle into that good arc,
Old plates should burn and rave at close of day;
Rage, rage against the drying of the slab.

Though wise sediments at their end know dark is right,
Because their chemistry had forked no lightning they
Do not go gentle into that good arc.

Good minerals, the last wave by, crying how bright
Their frail elements might have danced in a green bay,
Rage, rage against the drying of the slab.

Wild waters who caught and sang the sun in flight,
And learn, too late, they grieved it on its way,
Do not go gentle into that good arc.

Grave mantles, near death, who see with blinding sight
Blind LILIES could blaze like meteors and be gay,
Rage, rage against the drying of the slab.

And you, my Juan de Fuca, there on the sad height,
Curse, bless, me now with your fierce quakes, I pray.
Do not go gentle into that good arc.
Rage, rage against the drying of the slab.