EOS 240: Lab Assignment 1

Partial Melting of Olivine

Due: 2:30 pm January 22, 2026 (Th section)
Due: 1:30 pm January 23, 2026 (F section)

You have one week to complete this assignment. You should submit your response to the course Brightspace page as a single PDF file. **Additionally, we ask that you upload a copy of the scripts, code, or spreadsheets you used to complete the assignment. These documents will help us track down mistakes.** Responses to questions should be typed, using complete sentences and standard grammar. If you choose to support your answers with hand-drawn illustrations or hand-written calculations, you should scan or photograph the written work and integrate it into your PDF file as a figure. Double check that your image resolution is high enough to read. A google search of 'PDF combiner' will return a number of webpages that allow you to upload individual images and combine them into a single .pdf file (example: combinepdf.com). There are also a number of good apps for mobile phones. If you write your response in a word processor, please export to .PDF before submitting your response.

You are not excluded from working with others (pairs are recommended), but each person will submit their own copy of the assignment. In your submission, include the names of anyone you worked with on the assignment.

To answer the questions, you can perform calculations and make figures using Excel (an open source alternative: www.libreoffice.com), or with a program or programming language of choice.

Name : _____

Page:	2	3	4	**Total:**
Marks:	5	9	15	29
Score:				

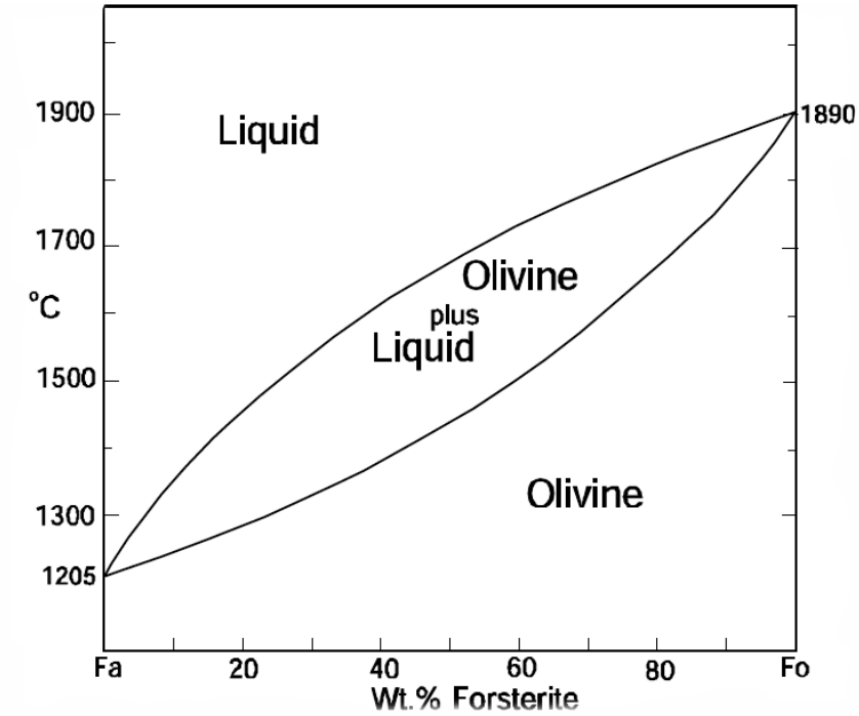

Figure 1: Phase diagram of Olivine. Fa is Fayalite (Fe_2SiO_4) and Fo is Forsterite (Mg_2SiO_4). Label this diagram with letters A–H as you answer question 1.

Question 1 (14)

Melting olivine

(a) (1 point) Suppose you mix 5 grams of pure fayalite with 15 grams of pure forsterite. Express the formula as weight fraction Fo_{xx} (grams of forsterite/(grams of forsterite + grams of fayalite)). Show your work.

(b) (2 points) Mark a point and label it "A" for the appropriate bulk composition of question (a) at 1950° C. Derive the degrees of freedom of the system at equilibrium under these circumstances (constant Pressure). Each degree of freedom represents an independent intensive variable in the system. What are the variables that correspond to your degrees of freedom?
Gibb's phase rule:

F = C - P + 1

Degrees of freedom = number of components - number of phases + 1

(c) (2 points) As composition 'A' cools, at what temperature will **P** change? Mark this point as 'B'. What occurs at this temperature? Label the solid phase as point 'C'. Describe the Forsterite composition of each phase present.

(d) (2 points) Describe what occurs as the system cools a few degrees from this point 'B'. What happens to the amount and composition of each phase?

(e) (3 points) Determine the ratio of olivine to liquid at 1700 °C. Label the temperature and composition of the liquid (D), the system (E), and the solid (F) on Figure 1.

(f) (2 points) At what temperature will equilibrium crystallization be complete? Why? What is the composition of the liquid (label as point G) and solid (label as point H) phase when the last drop of liquid disappears?

(g) (2 points) Fractional crystallization is the removal of crystals when they are formed so that they can no longer react with the liquid. How would fractional crystallization affect the composition of the final liquid and solid? Explain your answer.

Question 2 (15)

Olivine from ophiolites

An **Ophiolite** is a cross section through the oceanic crust and uppermost mantle that has been emplaced onto the continents through tectonic forces. The chemistry of rocks and minerals from Ophiolites helps us understand how oceanic crust is made. In this question, you will use an online geochemical database to look at the major element chemistry of *olivines* from ophiolites around the world. *Olivines* are common in upper mantle rocks (peridotite) and less common in the oceanic crust (gabbro).

Your first task is to download published data from the online repository EarthChem. EarthChem hosts many types of geochemical data, and we will specifically use the PetDB sub-database to search for igneous and metamorphic rock chemistry. Follow these steps:

1. Go to https://search.earthchem.org/
2. From this page, you have several search options. We will search "By Tectonic Setting" – click this button.
3. In the left box, select **OPHIOLITE** and then press the red "Add" button. You should see **OPHIOLITE** move to the right box.
4. Press "submit".
5. Click "Download Data".
6. On the next page, select "Mineral Samples" (we want to specifically look at mineral data for this question). Then, press "Continue to Analyte Selection"
7. Uncheck all minerals except for Olivine. Then, press "Continue to Analyte Selection".
8. In this next page, you can choose which data to download. Minimally, you will need to keep "FeO" and "MgO" – all other fields can be cleared (including "FeO" Total).
9. Now, you can download the data as an HTML Table, Text File (tab-delimited), or Excel spreadsheet. Select the output you prefer, and then click "View and Download Results". (You can also select "Show samples with all of the below values defined.")

For the next set of questions, we will focus on olivines that come from Lherzolites and Harzburgites (you can find the sample-specific label on your spreadsheet under the header "ROCK NAME").

(a) (1 point) Make a figure that shows Forsterite (Mg_2SiO_4) content on the x-axis and FeO on the y-axis. Use unique symbols for Lherzolites and Harzburgites (ignore other rock types). *Hint: how do you calculate Forsterite content from the MgO and FeO content of the olivines?*

(b) (2 points) Using the phase diagram from Question 1, annotate your figure above (part *a*) with an arrow that indicates the chemical pathway expected during equilibrium partial melting of olivine. Which rock type would you infer has experienced more partial melting, Lherzolites or Harzburgites?

(c) (2 points) Fill in the following table. A rough estimate is good enough here, and you will want to focus on the area where the data cloud is dense (there may be a few outliers).

Rock Type	Minimum Forsterite Content	Maximum Forsterite Content
Lherzolite		
Harzburgite		

(d) (3 points) Assume that the composition of the system before any melting occurs is equal to the Minimum Forsterite Content you selected for Lherzolites. How much partial melting (remind: we are assuming equilibrium melting here) is needed to explain the range of olivine chemistry observed in this dataset?

Rock Type	Estimate partial melt for minimum forsterite content	Estimated partial melt for maximum forsterite content
Lherzolite	0%	
Harzburgite		

Partial melts of peridotite are the source for the basaltic oceanic crust. When these melts stall and crystallize at depth (in the lower oceanic crust), we call that intrusive rock a gabbro. Olivine is an uncommon phase in gabbros, and these olivines have very distinct Forsterite contents when compared to olivines in Peridotite.

(e) (1 point) You will make a new figure for this question. Start with your figure from part (a) and add olivines that come from gabbro. Use unique symbols for Lherzolites, Harzburgites, and gabbros (ignore other rock types).

(f) (3 points) Let's hypothesize that the gabbro samples represent the equilibrium melt from the system you modeled in Question 2 (d). Use the gabbro data, your previous calculations (Q2 d), and new calculations to support or reject this hypothesis. *Hint: compare the estimated partial melting from the gabbro olivines, which precipitate from the melt phase, to the estimated partial melting from the peridotite olivines.*

(g) (3 points) With a written description (2 points) and an illustration or cartoon of oceanic crust formation (1 point), either **support** the hypothesis above or **come up with a new hypothesis** that can explain the observed olivine chemistry in the gabbros.