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EPSc 352: Earth Materials Fall, 2009
Homework #3: Binary Phase Diagrams

Due on Wednesday, September 30, 2009.

*Be sure to **label all units** on your values (e.g.,°C, mol., wt., %). **Write your answers on another page**, but put your labels directly onto the diagram that you are given here.*

☛Useful references, in addition to your class notes, are Ehlers' book (sent as a PDF; chapters 1 and 2 assigned as reading), Bloss's book (chapter 10, auxiliary reading sent as a PDF), and the Web site **http://www.brocku.ca/earthsciences/people/gfinn/petrology/phase.htm** (keep clicking on the forward arrows and also the blue-coded terms in the text).

1.a. What does the phase rule tell us about what happens as we consider increasing numbers of minerals that form from the same set of chemical components? [Write the phase rule, and consider this question.]

3pts

b. What happens to the statement of the phase rule if we decide to consider only P = 1 atm. pressure for our pressure conditions?

2pts

2. Refer to phase diagram **A** on the last page to answer the various parts of this question.

a. Label all the phase fields and any eutectic and peritectic points; use pens of different colors to designate the ***solidus*** and ***liquidus*** (label them).

10pts

b. Is there a reasonable way to split this diagram into two separate, free-standing diagrams? If so, how? If not, why not?

3pts

c. What is the composition of the point labeled Q--define the composition with respect to each of the appropriate pairs of phases on the diagram. [NOTE: When your binary compositional axis has 3 or more phases, each pair of phases can be used to define certain compositions.]

4

d. At 1800°C, what does the system Q consist of (i.e., what phase or phases does the point represent)? At 1600°C? At 1500°C? At 1420°C?

4

e. What is the meaning of the horizontal line at about 1475°C? [NOTE: This is not just an isotherm that I chose to show. This line is an integral part of the phase diagram; it divides that field into two different parts.]

2

f. **In detail**, describe what happens as material Q is cooled from 1800 to 1420°C.***

30 pts

*****Refer to the class hand-out written by former TA Channon Visscher, which demonstrates the level of detail expected here.**

Be sure to describe what happens to the relative amounts of and compositions of solids and liquids during cooling. ***Example: At such-and-such °C, the system Q consists of 20 (weight or mole?)% crystals and 80 (wt. or mol.)% liquid. The crystals are phase blah-blah. The liquid is of composition 46 (wt. or mol.)% Z and 54 (wt. or mol.)% Y.***

Specifically describe the state of the system at 1600°C and at just a little before and a little after any major transitions.

Describe what occurs (e.g., reaction, resorption, new precipitation) during the transition(s).

g. This phase diagram could be divided into 5 (compositional) parts, distinguished on the basis of which phases are precipitated and/or resorbed (dissolved). Sketch vertical lines to designate these 5 parts.

4

h. Consider the geologically common phenomenon, **fractionation**, whereby after material Q cools to some temperature, all the crystals are removed from the system; the remaining liquid continues to cool and precipitate crystals. Is there any way via fractionation that liquid from system Q could become more enriched in component $MgSiO_3$ than the composition of the eutectic? If so, describe it. If not, explain why not.

4

i. Consider all possible compositions in ONLY THE $MgSiO_3$-SiO_2 portion of this binary system. During the **heating** from 1400°C of any composition between $MgSiO_3$ and SiO_2, what is the composition of the first melt that possibly could form?

3

j. From your answers in parts (h) and (i) above, explain the significance of a **eutectic point**.

6

k. Look at the phase diagram as a whole. What is the technical description for this type of phase diagram? [Hint: Use terms like peritectic, eutectic, intermediate compound, congruently/incongruently melting, solid solution.]

2

l. Consider the geologic situation in which a liquid of composition F cools until it consists of a 50-50 (by wt.) mixture of forsterite crystals and melt, and then the liquid (call it L-2) is squeezed away from the melt (i.e., fractionated).

(1) Which minerals, and in what proportions, are the final products when liquid L-2 cools in an equilibrium, non-fractionating way?

3pts

(2) Is there anything that could be done with L-2 liquid in order to make it crystallize grains of an SiO_2 phase? What?

3pts

m. Briefly describe the melting of the mineral (pure) enstatite.

3

3. Refer to phase diagram **B** to answer the various parts of this question.

a. What is the technical description for this type of phase diagram? [Hint: Use terms like peritectic, eutectic, intermediate compound, congruently/incongruently melting, solid solution.]

2

b. Label all the phase fields on the diagram.

3

c. Why do both liquidus curves, on each side of phase B, have the same maximum temperature (see point Z)?

3

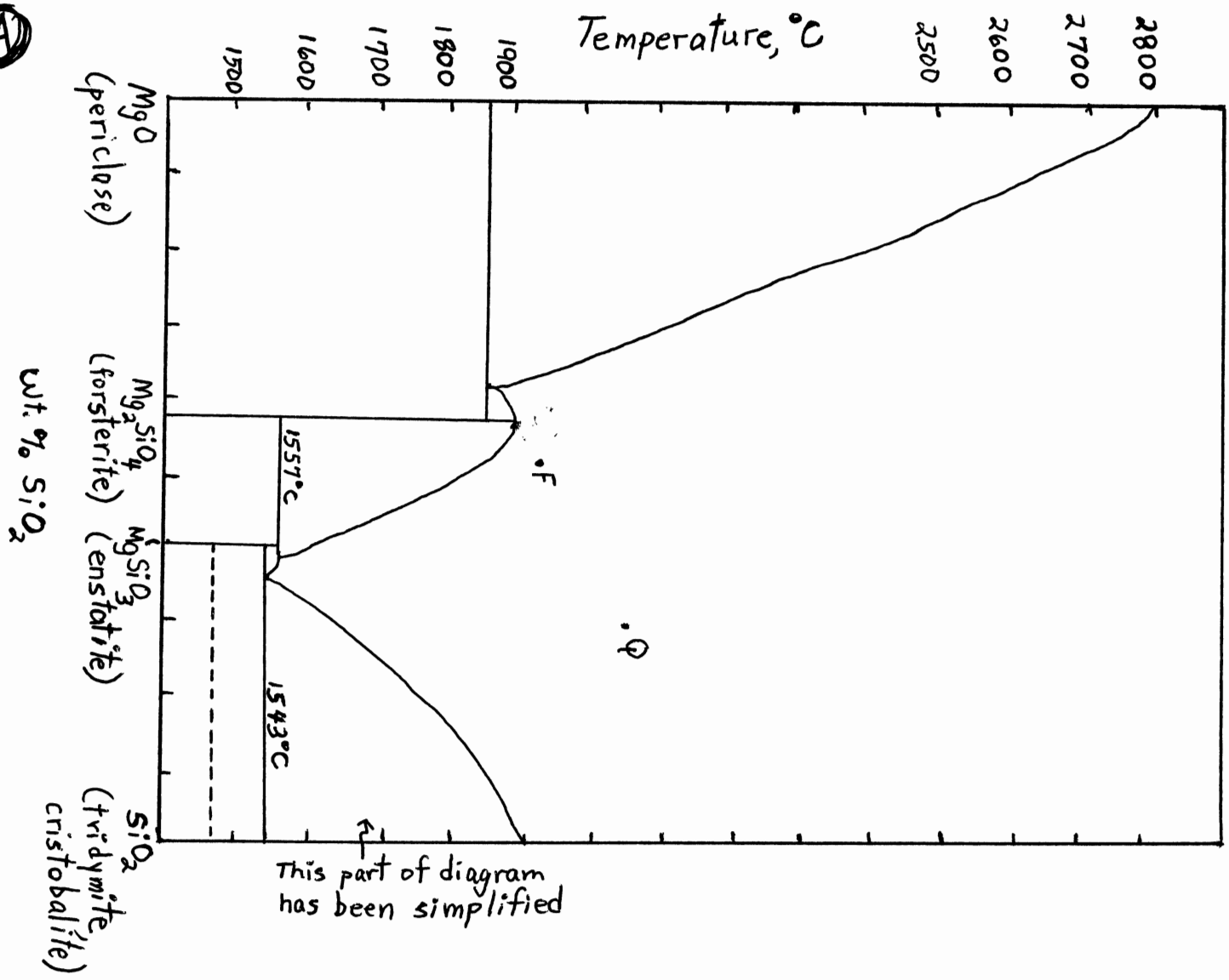
d. The diagram is drawn such that the solidus in the A-B part of the system lies at a different temperature than the solidus in the B-C part of the diagram. Can this diagram be correct? Explain your answer.

3

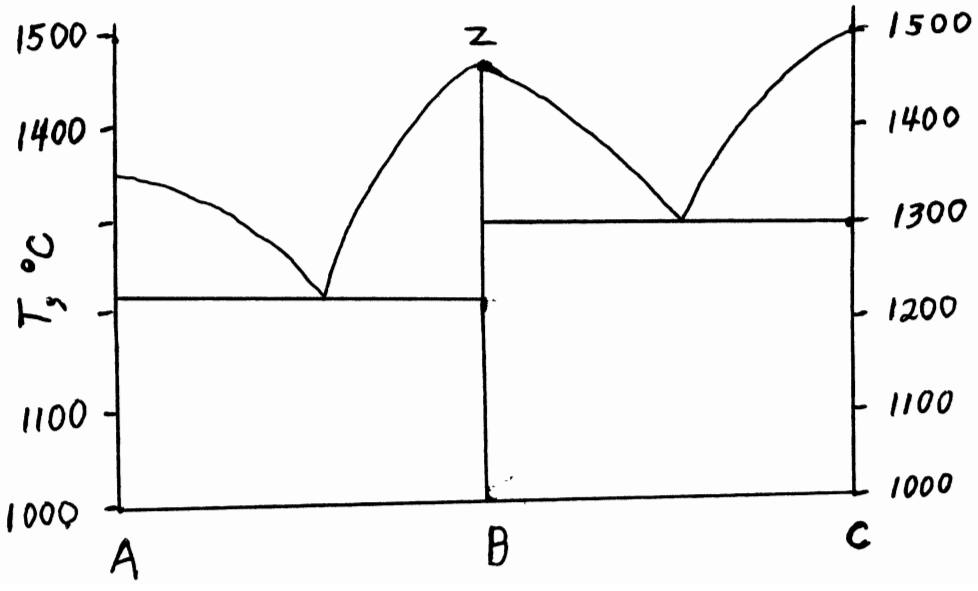
e. Briefly describe the melting of pure phase B.

3pts

(A)


Temperature, °C
1500
1600
1700
1800
1900
2500
2600
2700
2800
MgO (periclase)
Mg_2SiO_4 (forsterite)
$MgSiO_3$ (enstatite)
SiO_2 (tridymite, cristobalite)
wt. % SiO_2
1557°C
1543°C
F
Q
This part of diagram has been simplified

(B)


1500
1400
1100
1000
T, °C
Z
1500
1400
1300
1200
1100
1000
A
B
C