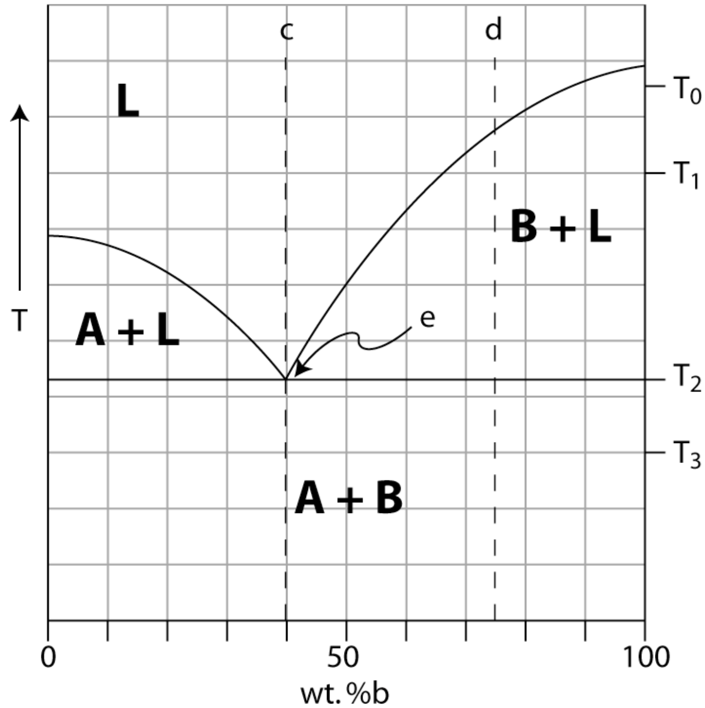
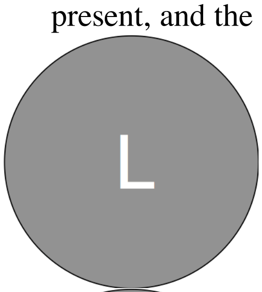
Question 1.



1A. Using the phase rule, determine the degrees of freedom:

a. at point e **F = 2 - 3 + 1 = 0**
b. within the field A + B **F = 2 - 2 + 1 = 1**
c. within the field A + L **F = 2 - 2 + 1 = 1**

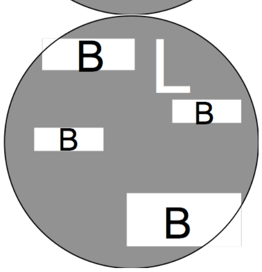
1B. Envision this system as a *slowly* cooling magma chamber. Start with a liquid of bulk composition *d* at T_0. In the circles below, show schematically the appearance of the system at temperatures T_0, T_1, T_2,+ 0.01°C (i.e., just above T_2) and T_3. When drawing, think about the crystallization process, not just the numbers! Also, try to portray the proportions of phases somewhat correctly. In the blanks, list the phases present, and the amount & composition of each. Not every text line will be needed.



Temperature = T_0
Phase **L**: Volume % = **100%**. Composition=**75% b**

Phase _______: Volume % = __________________ . Composition= _________

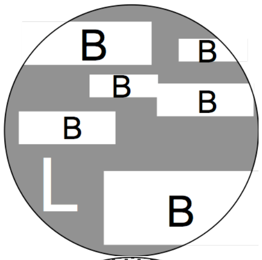
Phase _______: Volume % = __________________ . Composition= _________



Temperature = T_1
Phase **L**: Volume % = **74%**. Composition=**66% b**

Phase **B**: Volume % = **26%**. Composition=**100% b**

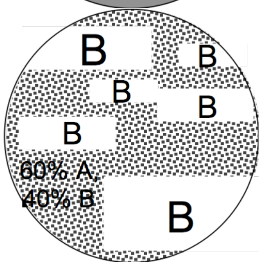
Phase _______: Volume % = __________________ . Composition= _________



Temperature = T_2 + 0.01°C
Phase **L**: Volume % = **42%**. Composition=**40% b**

Phase **B**: Volume % = **58%**. Composition=**100% b**

Phase _______: Volume % = _________________ . Composition= _________



Temperature = T_3
Phase **A**: Volume % = **25%**. Composition=**0% b**

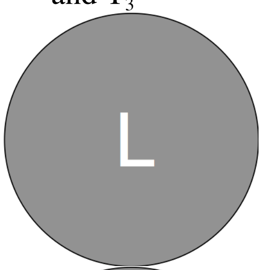
Phase **B**: Volume % = **75%**. Composition=**100% b**

Phase _______: Volume % = _________________ . Composition= _________

1C. For a given pressure, why can't the temperature of the system be lowered beyond T_2 until all of L has crystallized? (hint: use the phase rule)

Because at T_2, F = C - P + 1 = 2 - 3 + 1 = 0. So everything is known (i.e., specified) and cannot be changed, unless one of the phases disappears and we gain a degree of freedom.

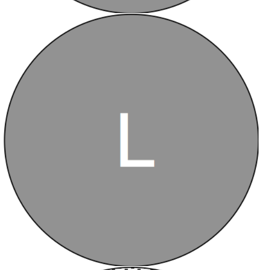
1D. Follow the instructions for 1B. above for a liquid of bulk composition *c* and temperatures T_1, T_2,+ 1 °C and T_3



Temperature = T_1
Phase **L**: Volume % = **100%**. Composition=**75% b**

Phase _______: Volume % = _________________ . Composition= _________

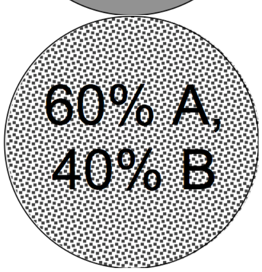
Phase _______: Volume % = _________________ . Composition= _________



Temperature = T_2 + 0.01°C
Phase **L**: Volume % = **100%**. Composition=**75% b**

Phase _______: Volume % = _________________ . Composition= _________

Phase _______: Volume % = _________________ . Composition= _________

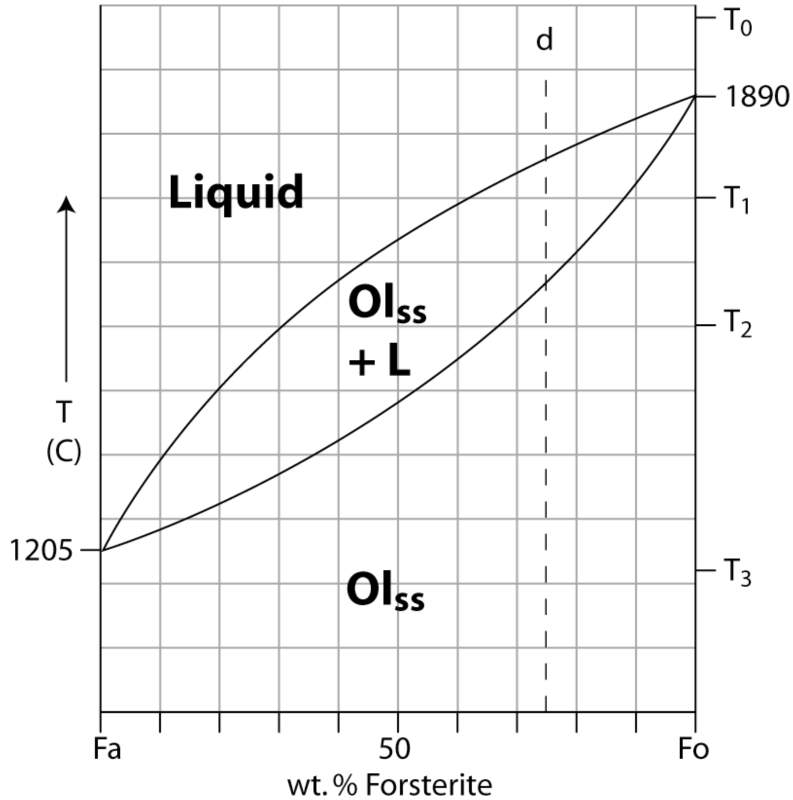


Temperature = T_3
Phase **A**: Volume % = **60%**. Composition=**0% b**

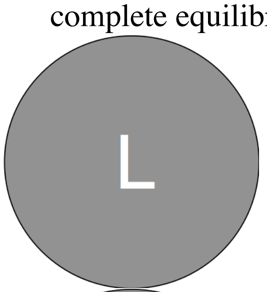
Phase **B**: Volume % = **40%**. Composition=**100% b**

Phase _______: Volume % = _________________ . Composition= _________

QUESTION 2



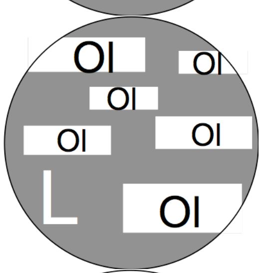
2A. Follow the instructions in question 1B for a liquid of bulk composition *d* at T_0, T_1, T_2, and T_3. Assume complete equilibration during cooling (relatively slow cooling). Describe the texture of the final product.



Temperature = T_0
Phase **L**: Volume % = **100%**. Composition=**Fo_{77}**

Phase _______: Volume % = __________________. Composition= _________

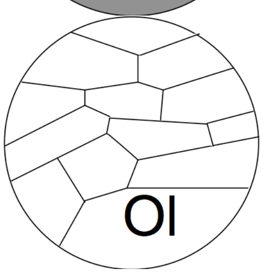
Phase _______: Volume % = __________________. Composition= _________



Temperature = T_1
Phase **L**: Volume % = **50%**. Composition=**Fo_{63}**

Phase **Ol**: Volume % = **50%**. Composition=**Fo_{87}**

Phase _______: Volume % = __________________. Composition= _________



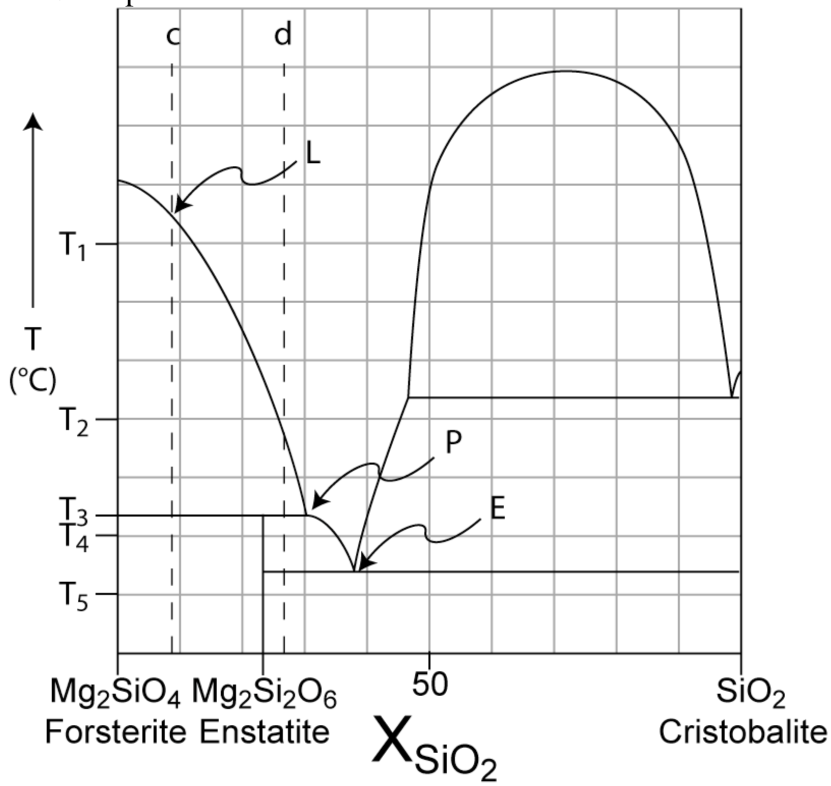
Temperature = T_2
Phase **Ol**: Volume % = **100%**. Composition=**Fo_{75}**

Phase _______: Volume % = __________________. Composition= _________

Phase _______: Volume % = __________________. Composition= _________

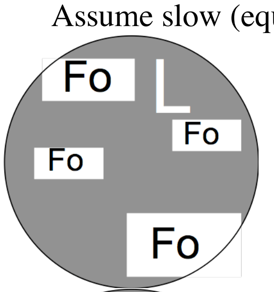
QUESTION 3

3A. Label each of the fields in this simplified phase diagram, except for the tiny one at the right. You may wish to use your text for help.



3B. Use the Phase Rule to determine the degrees of freedom at points P, E, and L

3C. Follow the instructions in question 1B for composition *c* at temperatures T_1, T_2, T_3 + 0.01°C, and T_4. Assume slow (equilibrium) cooling.

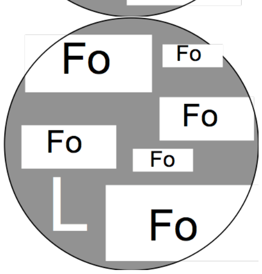


Temperature = T_1

Phase **L**: Volume % = **62%**. Composition=**13% SiO_2**

Phase **Fo**: Volume % = **38%**. Composition=**0% SiO_2**

Phase _______: Volume % = __________________ . Composition= _________

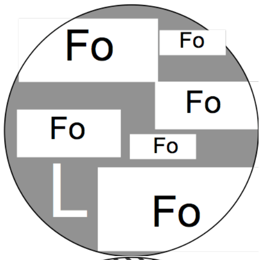


Temperature = T_2

Phase **L**: Volume % = **31%**. Composition=**26% SiO_2**

Phase **Fo**: Volume % = **69%**. Composition=**0% SiO_2**

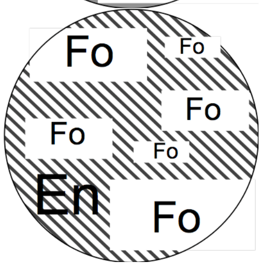
Phase _______: Volume % = __________________ . Composition= _________



Temperature = T_3 + 1 °C
Phase **L**: Volume % = **27%**. Composition=**30% SiO_2**

Phase **Fo**: Volume % = **73%**. Composition=**0% SiO_2**

Phase _______: Volume % = _________________ . Composition= _________

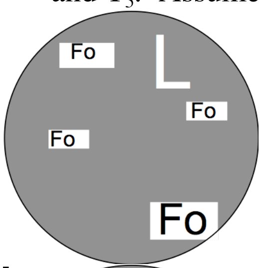


Temperature = T_4
Phase **En**: Volume % = **35%**. Composition=**23% SiO_2**

Phase **Fo**: Volume % = **65%**. Composition=**0% SiO_2**

Phase _______: Volume % = _________________ . Composition= _________

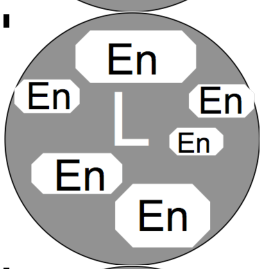
3D. Follow the instructions in question 1B for composition *d* at temperatures T_3,+ 0.01°C, T_3 - 0.01°C, T_4 and T_5. Assume slow (equilibrium) cooling.



Temperature = T_3 + 1 °C
Phase **L**: Volume % = **90%**. Composition=**30% SiO_2**

Phase **Fo**: Volume % = **10%**. Composition=**0% SiO_2**

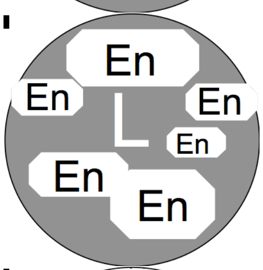
Phase _______: Volume % = _________________ . Composition= _________



Temperature = T_3 - 1 °C
Phase **L**: Volume % = **57%**. Composition=**30% SiO_2**

Phase **En**: Volume % = **43%**. Composition=**23% SiO_2**

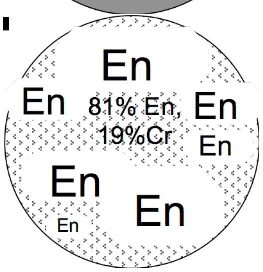
Phase _______: Volume % = _________________ . Composition= _________



Temperature = T_4
Phase **L**: Volume % = **67%**. Composition=**35% SiO_2**

Phase **En**: Volume % = **33%**. Composition=**23% SiO_2**

Phase _______: Volume % = _________________ . Composition= _________



Temperature = T_5
Phase **Cr**: Volume % = **5%**. Composition=**100% SiO_2**

Phase **En**: Volume % = **95%**. Composition=**23% SiO_2**

Phase _______: Volume % = _________________ . Composition= _________

3E. Given a solid of composition $Mg_2Si_2O_6$, at what temperature will the solid first melt? What will be the product(s) of melting? What are their compositions? **En will first melt at the peritectic temperature (T_3) to produce Forsterite crystals and a liquid of the peritectic composition (30%SiO_2).**