Mineral Reactions
This exercise will familiarize you with metamorphic reactions and how to use chemographic diagrams to portray those reactions. Chapter 26 will come in handy in answering the questions below.

1. Assume the following minerals and formulas (A, B, and C are fictitious elements):

   \[
   a: \text{ASiO}_3 \quad b: \text{BSiO}_3 \quad c: \text{CSiO}_2(\text{OH})_2 \\
   w: \text{C}_2\text{ASi}_2\text{O}_7 \quad x: \text{BCSi}_2\text{O}_6 \\
   z: \text{ABSi}_2\text{O}_6
   \]

   In a portion of a field area, the following mineral assemblages occur in equilibrium:

   \[a-x-z \quad b-x-z \quad a-x-c\]

   a. Draw an accurate A-B-C compatibility diagram (projected from quartz) for this area. Assume that quartz is present in all rocks as you answer the following questions.

   b. Can a quartz-bearing rock contain both z and c at this grade? Why or why not?

   No, because z and c are separated by the a-x tie-line.
c. As we traverse up metamorphic grade, we encounter the “w-in isograd.” Show/explain how you can use the chemographics to determine the approximate (unbalanced) reaction involved with this isograd #1. Draw the new chemographic diagram for the zone above isograd #1.

\[
a + c = w
\]

d. Balance the reaction.

\[
ASiO_3 + 2CSiO_2(OH)_2 = C_2ASi_2O_7 + SiO_2 + 2H_2O
\]

e. Illustrate the \( T-P \) dependence of the reaction on a \( T-P \) phase diagram (assuming \( p_{H_2O} = P_{lim} \)), drawing and explaining the appropriate shape of the reaction curve (see Figure 26.2). Also label the appropriate phases on each side of the curve.
f. Illustrate the $T$-$X_{\text{fluid}}$ dependence of the reaction on a $T$-$X_{\text{CO}_2}$ phase diagram (see Fig. 26.6; assume that the fluid is a CO$_2$-H$_2$O mixture), drawing and explaining the appropriate shape of the reaction curve. Also label the appropriate phases on each side of the curve.

![Phase diagram](image)

\[ T \]

\[ X_{\text{CO}_2} \]

\[ W + H_2O \]

\[ A + C \]

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g. At a higher grade yet, minerals $a$ and $x$ are no longer stable together. Show/explain how you can use the chemographics to determine the approximate (unbalanced) reaction involved with this isograd #2 (assuming that mineral $y$ does not become stable until higher grades).

By breaking the $a$-$x$ tie line and replacing with $z$-$w$ (and $z$-$c$) tie-line

\[ a + x = z + w \]

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h. Balance the reaction.

\[ 3\text{ASiO}_3 + 2\text{BCSi}_2\text{O}_6 = 2\text{ABSi}_2\text{O}_6 + \text{C}_2\text{ASi}_2\text{O}_7 + \text{SiO}_2 \]

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i. Why might some rocks show no evidence of the reaction? Be specific and refer to your diagram.

Not in the right composition space – rocks plotting above the $z$-$x$ tieline
j. What would you name isograd #2 and the zone above it? Why?

W Zone

k. Draw the compatibility diagram for the zone above isograd #2.

l. As we traverse up metamorphic grade, we encounter the “y-in isograd.” Show/explain how you can use chemographics to determine the approximate (unbalanced) reaction involved with this isograd #3.

\[ z + w + a = y \]

m. Balance the reaction.

\[ 2\text{ABSi}_2\text{O}_6 + 2\text{ASi}_2\text{O}_7 + \text{ASiO}_3 + \text{SiO}_2 = 2\text{A}_2\text{BCSi}_4\text{O}_{12} \]

n. Is isograd #3 a better or worse practical field isograd than isograd #2? Why?

\[ w \] will be present in more compositional space, whereas \[ y \] will only show up in A component-rich rock compositions.
o. Draw the compatibility diagram for the zone above isograd #3.

p. What are three possible reactions that may occur at the next isograd? (You need not balance them.)

\[ z + w = y + x \]
\[ z + x = b + w \]
\[ x + w = z + c \]

t. Assuming that you won’t be able to get into the field in the near future, what would you need in order to determine which of the three reactions should occur next, if at all?

Rock composition must fall in the space c-w-y-z-b