Homework No. 6
Composition Diagrams: Graphical Representation of Metamorphic Mineral Assemblages and the Relationships between Bulk Composition, Univariant Reactions, & Mineral Assemblages. Read the homework carefully and answer the questions. The reading from Winkler (page31-53) will be helpful.

There are several uses of triangular composition diagrams in metamorphic petrology.
Composition diagrams:
1) Provide a convenient way to illustrate changes in mineralogy with changes in metamorphic grade for a given bulk composition.
2) Aid in identifying reactions responsible for observed changes in mineral assemblages in rocks of constant bulk composition with the method of crossing tie lines.
3) Provide a way to illustrate the correlation of mineralogy with bulk composition at any given metamorphic grade.

This exercise will illustrate these uses.
As a young aspiring metamorphic petrologist, you are asked to interpret the following information. Two sedimentary units x and y have bulk compositions expressed in terms of mole percent of the following components:

	Al_2O_3	SiO_2	CaO
Composition x	10	47	43
Composition y	5	55	40

You are given a rock sample from each of these two bulk compositions at two sites in a metamorphic terrane, site A and B. These samples contain the following mineral assemblages:

	Site A	Site B
Composition x	Gr + Qz + Wo	Gr + An + Wo
Composition y	Gr + Qz + Wo	Wo + An + Qz

The bulk compositions of units x and y remain constant between sites A and B.

Plot the minerals from the two mineral assemblages and the bulk compositions at each site on two separate A—(Al_2O_3), C—(CaO), S—(SiO_2) composition diagrams (provided, on page 3) and label according to the site. For consistency, put Al_2O_3 at the top, SiO_2 at the right, and CaO at the left on all of the triangular diagrams. Minerals that coexist in an observed mineral assemblage are connected on these composition diagrams with a line, a tie-line. Connect up coexisting phases in each rock sample with tie-lines on both diagrams. When finished, you will find that the arrangement of tie-lines on the two composition diagrams are different because the mineral assemblages are different. When a mineral assemblage changes in a metamorphic rock, there has been a chemical reaction that has caused this change. We can identify the reaction responsible for the observed change of mineral assemblage by determining the change (s) in tie-lines between these two triangular composition diagrams. The reaction will be identified by the occurrence of crossing tie-lines: that is, one tie line will connect the two minerals that constitute the reactant side of the reaction, the crossing tie-line will identify the two minerals that constitute the product side of the reaction. If all the participating minerals actually plot in the plane of the triangular diagram, these will be the only minerals involved in the reaction, and you can balance the reaction using just these four minerals.

1). Compare the two composition diagrams you have constructed and identify the two crossing tie-lines (you can do this easily by overlaying the two diagrams).

2). Write the chemical reaction responsible for the observed change in mineral assemblage between the two sites. Remember, one of the crossing tie-lines connects the minerals that make up one side of the reaction, the other tie-line connects the minerals that make up the other side of the reaction. Petrologists generally call one set of these minerals the reactants, the other the products, of the reaction. Generally, the assemblage that is the higher grade (that is, higher temperature) assemblage is called the product assemblage. In this case, experiments have determined that Wo + An is the higher grade, or product assemblage.

3). Chemically balance this reaction. Note that the chemical compositions of all these minerals can be expressed in terms of the three components Al_2O_3, SiO_2, and CaO. The reaction assemblage is the four-phase assemblage identified by the crossing tie-lines. Note that both compositions x and y at site A contain the reactant assemblage Gr + Qz and both compositions x and y at site B contain the product assemblage Wo + An.

4). Compute the variance or degrees of freedom for these three-phase assemblages using the Phase Rule. Note that each of the three phase assemblages observed at the two sites is divariant. Thus a four phase assemblage would be univariant and would constitute the reaction assemblage (that is, both reactant and product assemblages).

5). Both bulk compositions started with the same mineralogy and have experienced the same reaction. Why then is there now a difference in mineralogy in these two units at site B? (Hint: Look at the positions of the bulk compositions and the resulting proportions of Gr, Qz, and Wo initially present in the two bulk compositions. Compare these proportions to the stoichiometry of the reaction you just balanced). What can you now say about the role of bulk composition in influencing mineral assemblage in metamorphic rocks?

Part B.1