

Alternative Activity 1.4

Description

In this activity the students will “explore and learn” about reaction progress variables individually or in a group.

Objective

The objective is to provide practice in use of reaction progress variables and gain an understanding of their upper and lower limits by exploration.

Preparation

1. The included a handout that the students should bring to class. It is provided in two forms: a .pdf file and an Excel workbook. The former can be used if the students will not have access to computers in class; the latter can be used if computers are available.
2. Determine how students will perform calculations in class, by calculators or computers, and make sure the necessary equipment will be there (tell them to bring it; schedule a computer lab; etc.).
3. No additional materials other than the slides and this lesson plan are needed.

Lesson Plan

1. Form groups for working on the activity unless it is being performed individually.
2. Go over the instructions with them, making sure that they understand that they should determine the range of possible values for each of the quantities that were calculated. If using the spreadsheet, tell them that they'll first have to enter the appropriate formulae in the blue boxes.
3. Tell them to start, but not to change the initial composition; they should only work with the given composition.
4. After they have had sufficient time to explore and determine ranges, ask them what they discovered. As they respond, record their points on the board for all to see. Points to try to raise are as follows:
 - a. Fractional conversion ranges from 0 to 1*
 - b. Extent is the same no matter which species is used to compute it
 - c. Extent ranges from 0 to 0.2
5. *Someone may say that they found conversions greater than 1 in response a. above; if they don't ask if anyone found a conversion greater than 1. Ask questions or lead discussion to recognize that in this case each time the conversion became greater than 1, it was for oxygen and at the same time the moles of oxygen became negative. *Alternatively, some may say that the upper limit is 0.8. Ask questions or lead discussion to recognize, first, that in this case oxygen is the limiting reagent and that its conversion can range from 0 to 1 whereas ammonia is not the limiting reagent and so its conversion can only range from 0 to 0.8. Also note that whenever either of these upper limits is exceeded, the moles of oxygen becomes negative which is physically impossible.
6. Have them repeat using 2 initial moles of oxygen (so that ammonia becomes rate limiting). Points to bring out in discussion include the following:
 - a. Now conversion of ammonia ranges from 0 to 1, but that of oxygen ranges from 0 to 0.625
 - b. The extent now ranges from 0 to 0.25 (leading to the conclusion that the range for the extent depends upon the initial amounts; how surprising since it is an extensive variable).

7. Have them repeat using the following one mole of each species initially present. In the subsequent discussion, ask questions or lead to the following points.
 - a. Both the conversion and the extent can become negative in this case; this means the reaction actually proceeded in the opposite direction from the way it was written. (You may need to prompt this discussion by having them insert a value greater than 1 for the moles of ammonia; they may never have considered this possibility because they assumed the reaction would go forward).
 - b. In conjunction with point a, ask how they can know whether a calculated conversion or extent is acceptable; the answer is that the moles of all species must be greater than or equal to zero. Point out that they may encounter situations like this, especially when more than one reaction takes place because it can then sometimes be harder to know at the start which direction every reaction will go.
8. Conclude the activity with the slide showing the summary.
 - a. Emphasize the limiting values of conversions and extents of reactions, their units, and the fact that the conversion depends upon the identity of the species used to define it.

Variations

Before distributing the worksheet, pre-populate it with the formulae for calculating each of the quantities. Alternatively, have them fill in the formulae as a homework assignment and bring the spreadsheet to class ready to use.

Turn it into a contest: find a final moles of ammonia that gives

Tips and Suggestions

Don't dwell on the negative conversions and extents; re-emphasize that AS LONG AS THE REACTION PROCEEDS IN THE DIRECTION WRITTEN THEN the conversion of the limiting **reactant** will range from 0 to 1 and the conversion of other reactants may have an upper limit less than 1 that depends upon the initial composition.