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In the Classroom

The Tile Game

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A simplified method of teaching dimensional analysis to students that can be used in a liberal arts, nonmathematical chemistry course is presented in the form of a game or puzzle that can be played by the student. This game is designed to counter the mathematical anxiety that many students bring to such courses. The result of the game is that certain concepts in chemistry relating to numbers can be taught in a fun interactive manner.

The purpose of the Tile Game is to convince … students that dimensional analysis is really just an easy way to solve problems.

Introduction

Boise State University offers a course called Concepts of Chemistry which satisfies the university core science requirement. Although this course is intended as a nonmathematical presentation of chemistry, certain chemistry concepts require number manipulation. The trick to overcoming this is to let the students in the course solve certain problems in a mechanical way that requires only multiplication or division rather than formal algebra.

The dimensional analysis method allows students with little or no algebra background to solve many of the problems encountered in chemistry. Dimensional analysis uses conversion factors (fractions whose numerators and denominators are equivalent) to change the units from one form to another. For

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example, the problem of how many inches are in 1 mile can be readily solved by this method if a student knows the conversion factors of 5,280 feet = 1 mile and 12 inches = 1 foot.

$$1 \text{ mile} \times \frac{5{,}280 \text{ feet}}{1 \text{ mile}} \times \frac{12 \text{ inches}}{1 \text{ foot}} = 63{,}360 \text{ inches}$$

Unfortunately, when this method is taught, especially to nonscience majors, many of the students are intimidated by the algebraic nature of the presentation. The purpose of the Tile Game is to convince these students that dimensional analysis is really just an easy way to solve problems. The game has been used effectively for helping students in any first-year chemistry course, regardless of the mathematics prerequisite for the course.

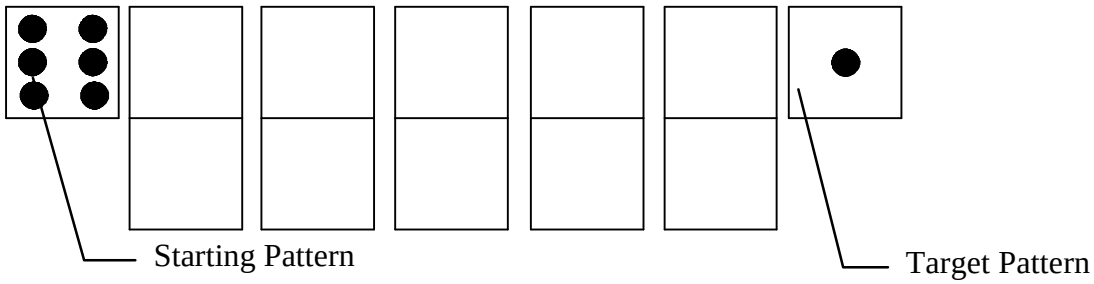
The Tile Game

Object of the Tile Game

The objective of the game is to change the starting pattern of dots into the desired pattern by using the smallest possible number of tiles.

Rules of Play

You must match the starting pattern of dots with the identical pattern of dots in the lower half of the first tile that is played. In multiple tile solutions, each subsequent tile must have its lower pattern of dots match the pattern of dots on the upper half of the previous tile. They match diagonally from upper left to lower right as shown in the one tile solution to the game. Play continues until the target pattern is present as the upper half of the last tile played.



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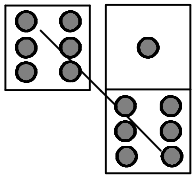
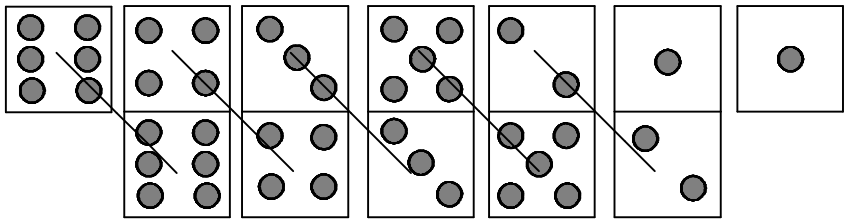
A One Tile Solution



The student is not given all of the possible tiles. For example, tiles could be selected to solve the problem in five steps. A five-step solution to the above game is shown in the following diagram.

Solution



The Metric Conversion Game

This game is played with the same rules as the Tile Game but requires the students to perform division or multiplication to arrive at the answer. Two tiles are constructed for each of the conversions. One has the units $\frac{A}{B}$ and the other has the units $\frac{B}{A}$. All of the spaces shown for tiles do not have to be filled in order to arrive at the target pattern.

An example game converting kilometers to millimeters is shown in the following diagram. Only two tiles were necessary in order to arrive at the solution.

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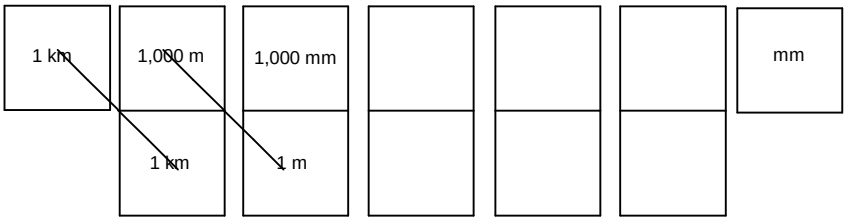
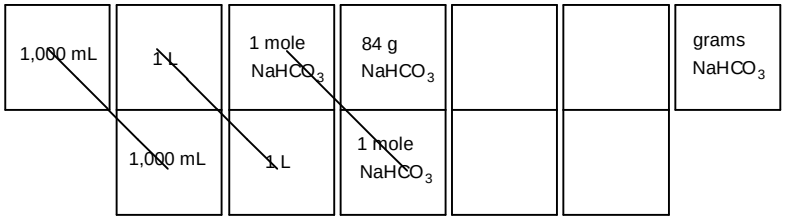


The Molarity Game

This game is played with the same rules as the other tile games but the tiles are constructed to include all possible conversion factors relating to the problem.

An example game which determines the grams of $NaHCO_3$ present in 1000 mL of a 1 M solution of $NaHCO_3$ is shown in the following diagram.



The Stoichiometry Game

This game is played with the same rules as the Tile Game but the tiles are constructed to include most of the possible conversion factors relating to stoichiometry. A balanced chemical reaction is given to the students. Reactions that involve one-to-one mole relationships are the first to be used because they do not involve division or multiplication. More complicated reactions can be used but not all numbers will cancel, so the game needs division or multiplication calculations to arrive at the correct result. The experience gained with the Metric Game should make this an easier transition. Limiting reagent problems can be done effectively and, if the students do not solve the game for each given reagent separately, they will soon find that there is no tile that will get them out of the quagmire that they have created.

An example game might ask how many grams of sodium chloride will be formed by the reaction of 40 grams of NaOH with excess HCl?

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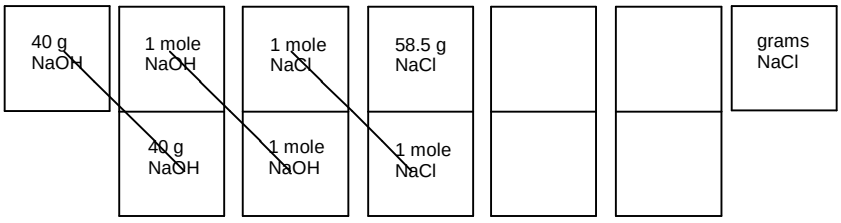
$$NaOH + HCl \rightarrow NaCl + H_2O$$

Because most of the tiles for all possible conversions are given to the students for this problem, they must make thoughtful selections. They quickly learn that they must use the important conversion factor of 1 mol NaOH = 1 mol NaCl or they will be unable to finish this game.

Solution



Conclusion

Most students find the first game easy and fun to solve. They obtain a confidence that carries into the other games. As a result of playing these games, the intimidation caused by these types of problems is diminished and most learn the dimensional analysis method quite readily. The game is intended to give students more insight into how the method of dimensional analysis can help them arrive at the conversion factors needed to solve problems. Although a limited sampling, the Concepts of Chemistry class felt that the game was enjoyable and beneficial. The game and tile sheets can be given to students so that they can cut out the tiles and play the game at home after being shown how to play in-class. Letters or symbols can be used in place of the dots and offer more complexity for the first game. Dominos™ could also be used as the tiles for the first game. The game as presented to the students, including templates for the tiles are available in the supporting document (handout.pdf 184 Kbytes).