A Fully Assignable Electronic Textbook

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I. Introduction

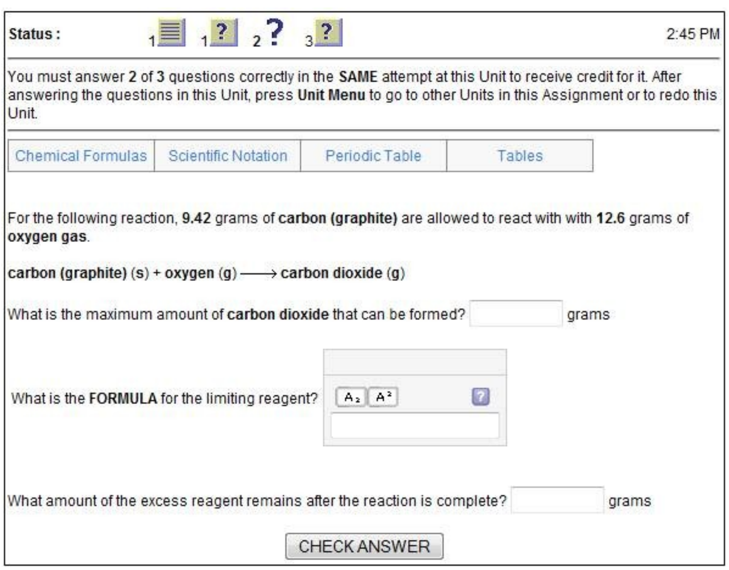
Electronic homework systems are now approaching, or exceeding, twenty years in use. They have evolved from simple multiple choice question banks to the use of randomly selected "question pools" to the use of both numerically and chemically randomized parameters. More recently, stepwise tutorials and interactive simulations, animations, and videos have been included as part of homework assignments. We have worked on integrating these assignment types in the general chemistry OWL (Online Web-Based Learning) system for the last 15 years or so. They system now contains thousands of randomized homework assignments, each with extensive randomization and feedback. This note highlights our current work creating an integrated hybrid textbook that contains a hardcopy version and an online version that fully immerses assignable content throughout the text narrative.

II. A Review of Interactive Homework Modules

The OWL system contains the following types of modules:

A. Core OWL Mastery Assignments

These modules most often offer the student a set of three questions and ask them to solve two of them correctly to gain mastery credit. However, each of the three "questions" might well require multiple correct responses. An example problem (on limiting reactants) is shown below. This problem counts for one of the two they need to complete.



When the student enters an answer, they receive feedback on whether they are correct, as well as a full solution to the problem.

Feedback:

1. Write a balanced chemical equation for the above reaction:

$C (s) + O_2 (g) \longrightarrow CO_2 (g)$

2A. Determine the number of grams of **carbon dioxide** that can be formed from the available **9.42** g of **carbon (graphite)**:

$$9.42 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} \times \frac{1 \text{ mol } CO_2}{1 \text{ mol C}} \times \frac{44.01 \text{ g } CO_2}{1 \text{ mol } CO_2} = 34.5 \text{ g } CO_2$$

2B. Determine the number of grams of **carbon dioxide** that can be formed from the available **12.6** g of **oxygen gas**:

$$12.6 \text{ g } O_2 \times \frac{1 \text{ mol } O_2}{32.00 \text{ g } O_2} \times \frac{1 \text{ mol } CO_2}{1 \text{ mol } O_2} \times \frac{44.01 \text{ g } CO_2}{1 \text{ mol } CO_2} = 17.3 \text{ g } CO_2$$

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3. It is possible to form **34.5** grams of **carbon dioxide** from the available **carbon (graphite)**, but only **17.3** grams of **carbon dioxide** can be formed from the available **oxygen gas**.

The limiting reagent is O_2. All **12.6** g of O_2 will be used and **17.3** grams of CO_2 will be formed.

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4. Calculate the amount of **carbon (graphite)** that is used by reation with the **12.6** g of **oxygen gas**.
Keep an extra significant figure here and round after step 5.

$$12.6 \text{ g } O_2 \times \frac{1 \text{ mol } O_2}{32.00 \text{ g } O_2} \times \frac{1 \text{ mol C}}{1 \text{ mol } O_2} \times \frac{12.01 \text{ g C}}{1 \text{ mol C}} = 4.729 \text{ g C}$$

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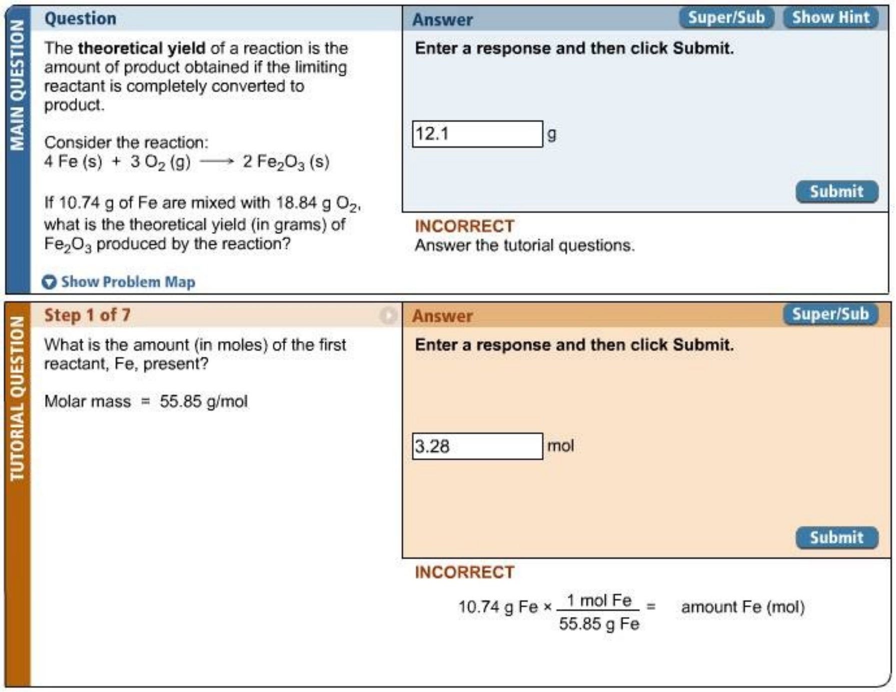
5. Calculate the amount of C that remains in excess.

9.42 g C originally present - **4.729** g C used = **4.69** g C in excess

If the student does not answer correctly, a new version of the question is offered that has different numbers, different chemical systems, and, often, different wording.

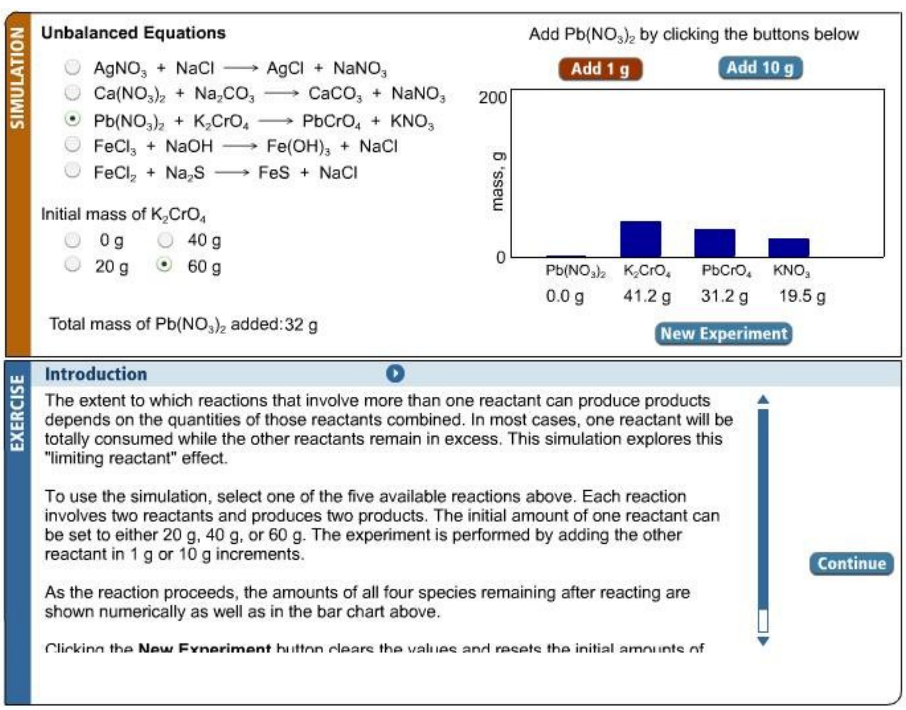
B. Tutorials

Each major problem type includes a step-by-step tutorial. These modules ask a typical question, and should the student answer incorrectly, the module asks a series of simpler questions to lead them through the solution to the problem. The example below shows the first tutorial step for a similar limiting reactant question. This example is linked here.



C. Interactive Conceptual Simulations

Each major concept is supported by one or more simulation, video, or animation-based exercises. These exercises typically give the student a panel with which they explore a chemical system as well as a guided-inquiry panel that asks questions that lead them through the exploration. These modules are also given to the instructor without the leading questions so they can be used during class. This module is linked here.



III. Traditional Linking of Texts to Online Homework

To date, electronic homework systems have been used in conjunction with traditional textbooks by two-directional annotations. In the text, each particular area that has a supporting homework module notes the presence of the module and directs the student to go work on it. In the homework, each module notes where to find in the textbook the information to help understand and solve the problem at hand.

IV. The Integrated Approach

The genesis of this project comes from the following questions: Why are the homework and the text separate? Can they be an integrated, single, assignable unit? The purpose of the project is to create a single, integrated system where traditional items within a text become assignable modules in the homework system, but not in a separate way. The goal is to make a system where reading the textbook is working the textbook, and working the textbook is doing your homework.

Textbooks have a particular structure for a reason- certain concepts and skills naturally precede other concepts and skills. Because of this, we have fully retained the traditional textbook structure:

- Chapter 1
  - Section 1.1
    - Subsection 1.1a
    - Subsection 1.1b
    - Section 1.1 Summary Assignment
  - Section 1.2
    - Subsection 1.2a
    - Subsection 1.2b
    - Subsection 1.2b
    - Section 1.2 Summary Assignment
  - Section 1.3
    - Subsection 1.3a
    - Section 1.3 Summary Assignment
  - Chapter 1 Summary Assignment
    - Challenge Problems
    - Chemistry and You Problems
- Chapter 2…

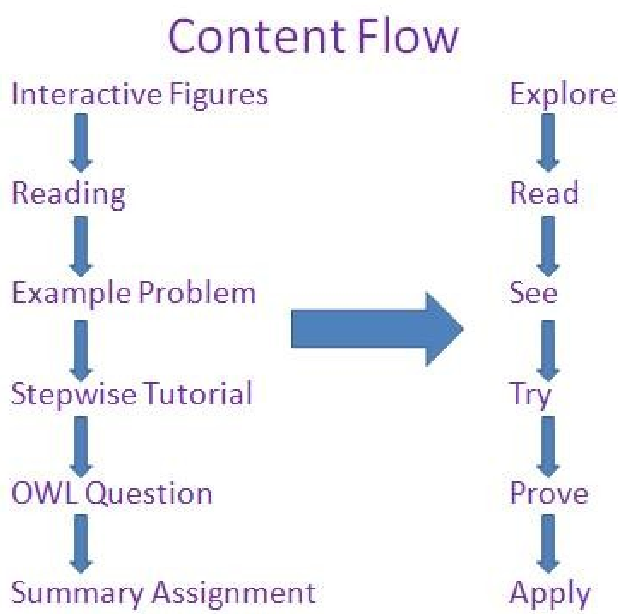
Each Section begins with an "Opening Exploration" that, while relatively easy, gives the students a flavor for what concepts will be introduced and what purpose they serve. An example is linked here. The core content then resides in Subsection pages. These typically have a number of elements:

- Text
- Interactive Figure (assignable)
- Text
- QuickCheck Question (assignable)
- Example Problem Suite
  - Static Example Problem with hidden, expandable solution
  - Video Solution, narrated whiteboard walkthrough of the static solution
  - Stepwise Tutorial (assignable)
  - Mastery Question (assignable)
- Text …

Interactive Figures are assignable versions of problems that turn photos into videos, charts into simulations, and graphic art into animations. These have a series of questions that lead the student to pay attention to the aspects of the figure that are important to note. Examples are linked here and here. QuickCheck questions are simple reading comprehension questions and are there- frankly- just as an incentive to get the student to pay attention to the reading.

Throughout the text, the difficulty of assignments is "ramped up" from concepts to practice problems to mastery assignments to challenge problems. Modules that introduce concepts (interactive figures and tables) are generally supported by fairly easy questions- the idea is to get the student to pay attention to what is being covered. Example problems begin with a stepwise tutorial that is generally fairly easy to work through because of the detailed, step-by-step help. Mastery questions are more difficult because the student must start over with a new version of the question if they get it wrong. Section summary assignments are more difficult yet because they require students to answer multiple questions in a single setting, and the questions are less defined. Finally, the chapter summary assignment is most difficult because the questions are not categorized for the student, and the most challenging questions are asked in that section. This progression starts at exploration and moves through mastery of the material and finally the ability to apply it.

This pedagogical flow through the assignable content is summarized in the figure below.



V. Other Features and Plans

Through testing and interviews with students and instructors, we recognize the necessity of a physical hard copy text. The plan is to provide a text that includes all the narrative, figures and example problems, but not the summary assignments. Those assignments are intended for online work. The text will therefore be relatively brief compared with more traditional texts. The online version will include the kinds of tools one expects: bookmarking and note taking, instructor insertion of notes and links, tools for student-student and instructor-student communication.

Creation of the assignable text involves creation of the text, and of the assignments. The pieces are then built into the electronic book system and into a physical text. This process is nearing its completion and we have performed tests on sample classes using mostly but not fully functional test systems. In general, students find the integrated approach useful and we find an average of 4-5 hours of student work to move through a chapter. Further limited-scale testing is planned for Spring 2011 semester and use by a wider group of larger classes is planned for the Fall 2011 semester.

The completed assignable text will be published and distributed by Cengage Learning, who has licensed and distributed the OWL system for the last decade.