Reactants, Products and Leftovers

PhET Sim Design Document

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This document is very out of date. Lots of decisions not captured herein about the "Sandwich Shop" and "Real Reactions" tabs. So beware that the implementation doesn't necessarily match this document. -Chris 11/19/09 11:35 AM

Contents

Learning Goals

"The student will be able to... *verb noun*."

1. Recognize that atoms are conserved in a chemical reaction
2. Describe the difference between coefficients (e.g. 3 in $3A_2$) and subscripts (e.g. 2 in $3A_2$) in a chemical equation
3. Predict the products and leftovers after reaction
4. Identify the limiting reagent in a chemical reaction

Synergistic goals
5. Relate chemical reactions to everyday experiences like making sandwiches
6. Translate from symbolic (e.g. CH_4) to molecular representations of matter

Note for Teaching Tips:

Sim does NOT address the concept of moles!

Common Misconceptions

1. Limiting reagent = lowest coefficient
For the balanced equation $2A + B \rightarrow A_2B$, students pick B as the limiting reagent without using the *amounts* of the reactants.

2. Limiting reagent = least amount
Students use the amount of each reactant (e.g., A = 3 moles, B = 2 moles) but ignore the *molar ratio* in the balanced equation; i.e., they pick B as the limiting reagent.

TL: the idea below comes from the NDSL Science literacy map
http://strandmaps.nsdl.org/?id=SMS-MAP-1349
Middle- and high-school student thinking about chemical change tends to be dominated by the obvious features of the change. For example, some students think that when something is burned in a closed container, it will weigh more because they see the smoke that was produced. Further, many students do not view chemical changes as interactions. They do not understand that substances can be formed by the recombination of atoms in the original substances. Rather, they see chemical change as the result of a separate change in the original substance, or changes, each one separate, in several original substances. For example, some students see the smoke formed when wood burns as having been driven out of the wood by the flame.

Basic Sim Operation

Students use slider to enter reactants into "before reaction" box - can see all reactants in the box
Based on chemical equation, products and/or leftovers appear in "after reaction" box
Rationale: important to show before & after at same time, so students can see that number of atoms is conserved

Students can also vary reactant coefficients in chemical equation (except in 3rd tab) - this changes what appears in "after reaction" box
Rationale: gives students immediate feedback on the effect of molar ratio

Each tab operates in a similar manner, but with different representations (and allowances)
Rationale: students familiar with controls when they reach the more abstract tabs, can focus more on concept; scaffolds

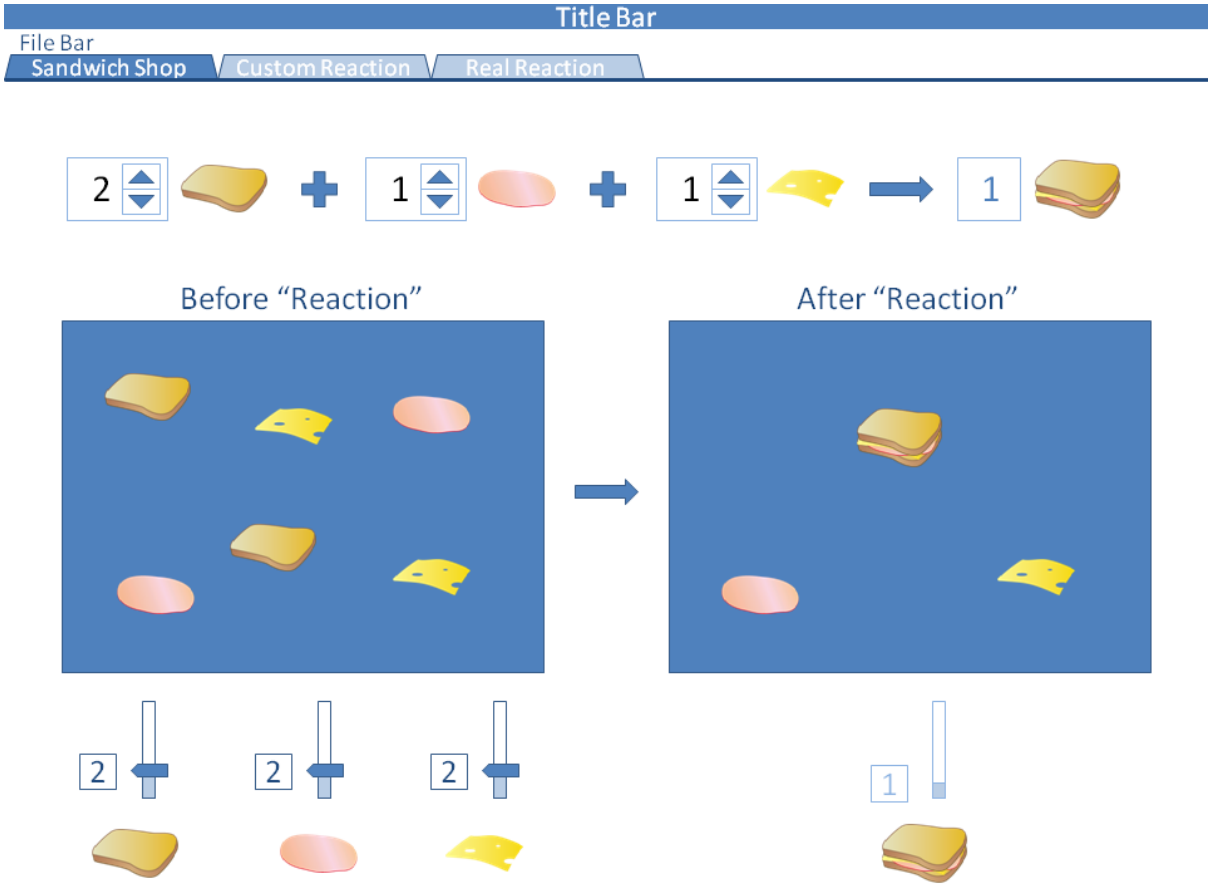
Order of tabs:
1. "Sandwich Shop" = real-world analogy
2. "Custom Reaction" = generic microscopic representation
3. "Real Reaction" = real-world, relevant chemical equations with symbolic representation

1st tab: "Sandwich Shop" aka real-world analogy

Students can vary the coefficients of the sandwich "equation" to make different sandwiches
Analogy = sandwich recipe is like chemical equation; can have leftover ingredients due to "limiting reagents"

Note for Teaching Tips:
The analogy relates the *amount* of food to the number of *molecules* (or moles) of reactants – not to the number of *grams* of reactants!

Example of case with limiting reagent:



Due to finite size of "before reaction" box, need to set an upper limit on number of "reactants" that students can add to box.
Range for slider: 0-10? (Same for each tab)

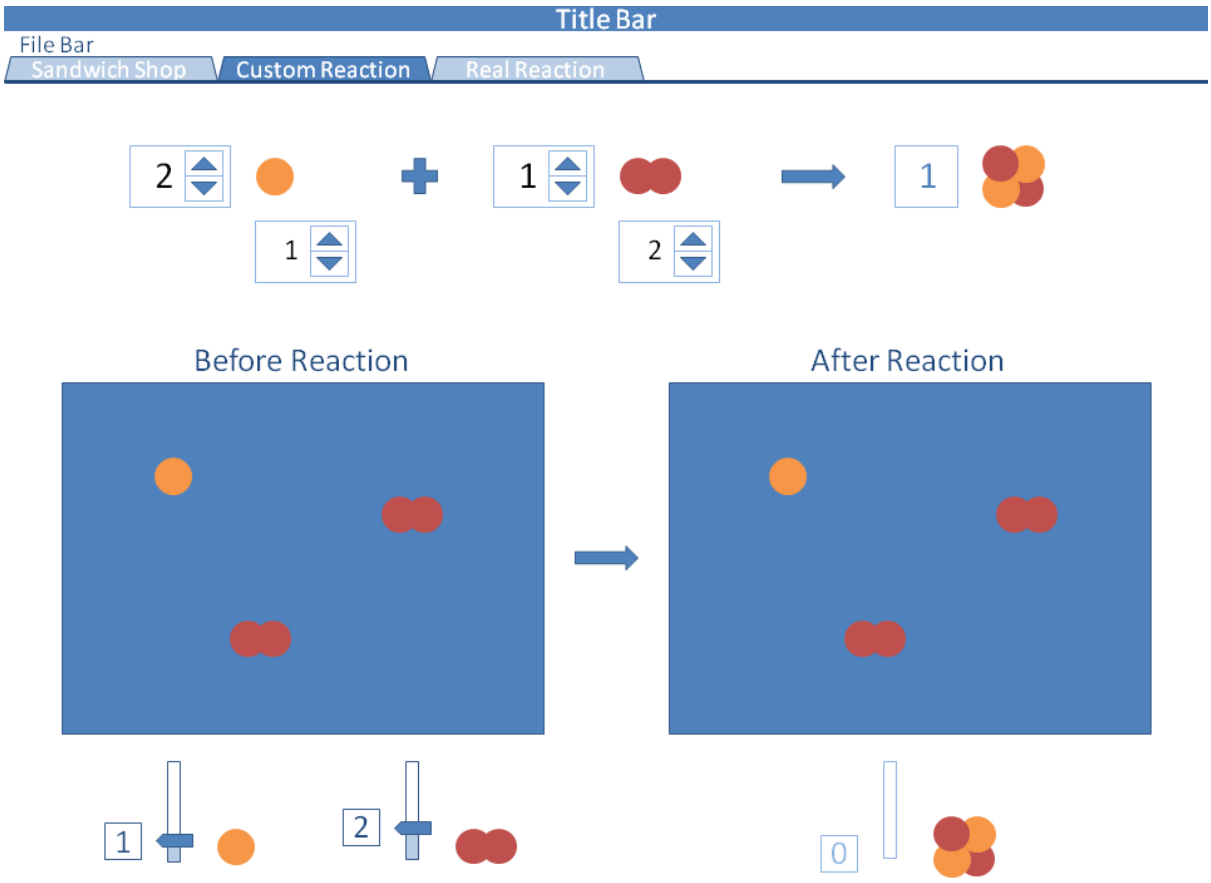
Size of sandwich will vary with coefficients - need to limit range of coefficients.
Range for spinner: 0-3? (Same for each tab, except 3rd)
Note: all coefficients can go to zero. In the case of no reactants, no products will show in the equation.

2nd tab: "Custom Reaction" with microscopic representation

This tab was dropped because this representation didn't really add anything. And the board didn't want students changing identity of reactants (subscripts). -Chris 11/17/09 5:54 PM

Students can vary both:
1) coefficients of chemical equation
2) identity of reactants (aka subscripts)
Rationale: gives students immediate feedback on difference between coefficient and subscript

Example of case where reaction cannot occur:



Can show motion in sim; but should we? Answer: NO!
Reasoning is because the sim is to emphasize the before and after snapshot to allow students to easily compare how things add up to determine what is left over. Motion would make it much more difficult to follow and see that the number of "atoms" is conserved. -Katherine Perkins 9/28/09 10:57 AM

Size (and shape) of product will vary with subscript - need to set a limit on subscript
KP: let's just do 1-3 ... 0 doesn't make sense and 4 seems excessive

Why are we using spinners to change coefficient/subscripts and sliders for changing quantities in the boxes? Why aren't we consistently using the same control for the same purposes (ie, to change value)? I suggest using spinners everywhere. -

cmalley@pixelzoom.com 9/23/09 11:43 AM
On 11/5/09 we decided to use spinners instead of sliders. Both approaches we implemented. Spinners were better for discrete (integer) values, don't require a custom component, show the histogram more clearly, and take up less space. -Chris 11/19/09 11:39 AM
KL: important to show amount in box *visually* (as well as numerically)
CM: it would be better to create our own histogram widget, a vertical bar (much like a slider's track) that fills up with a color based on the value (sort of like a rectangular thermometer). The widget under the Reactants box would have a handle (similar to a slider knob) that lets you increase/decrease the histogram value. The widget under the Products box would look the same, but without the knob.

Suggestion: Position the subscript values where they would normally be in an equation; that is, slightly (but not fully) below and to the right of the "balls". Imho, their current position doesn't clearly say "I am a subscript". -cmalley@pixelzoom.com 9/23/09 11:53 AM
KL: good idea, but subscript hard to define using ball representation

Balls will look more 3D - aka, spheres
CM: can implement using SphericalNode from PhET common code

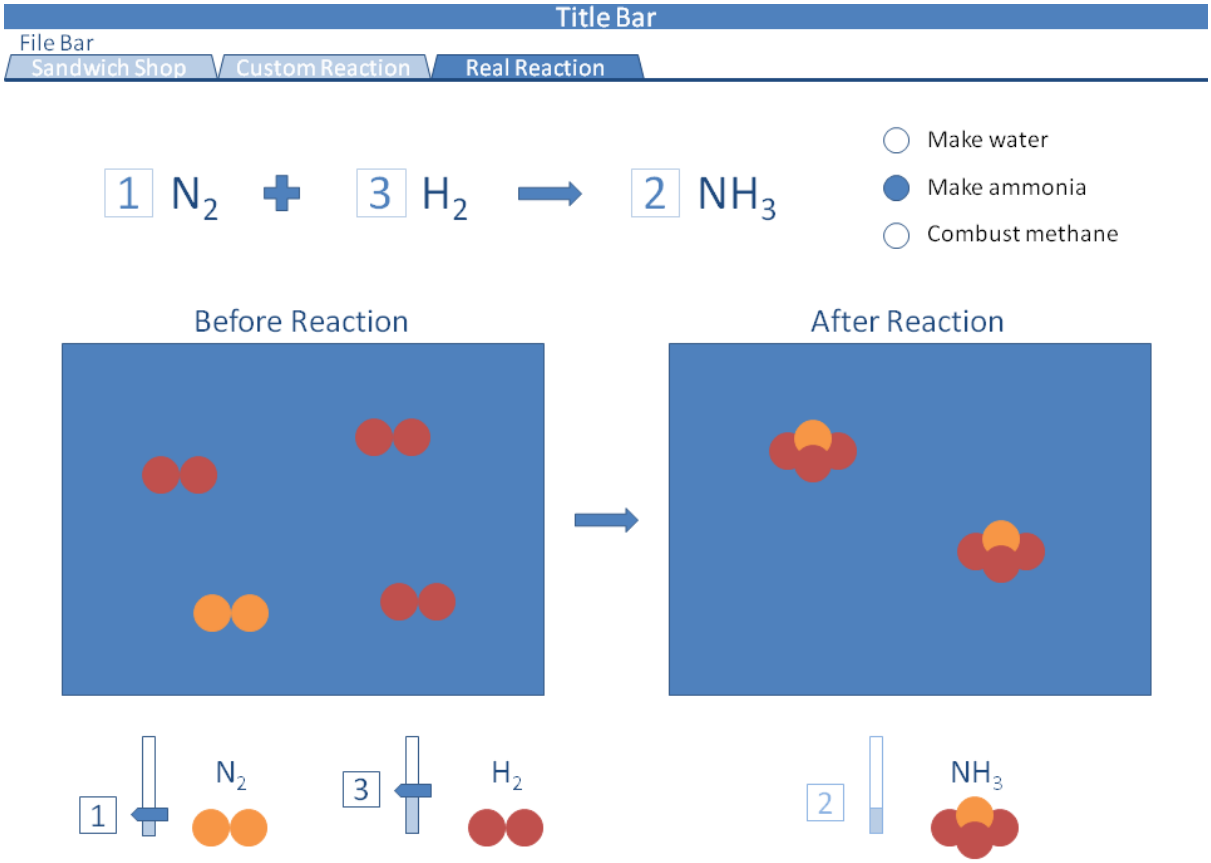
3rd tab: "Real Reaction" with symbolic representation

Students can choose among 3 *real* reactions; cannot change chemical equation

Chemical equations:
1. Make water: $2H_2 + O_2 \rightarrow 2H_2O$
2. Make ammonia: $N_2 + 3H_2 \rightarrow 2NH_3$
3. Combust methane: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$; NEW: 2 products!

Are 3 choices sufficient? If you think you'll want to have more, use a combo box (aka, option menu) instead of radio buttons. -cmalley@pixelzoom.com 9/23/09 12:23 PM
KL: good question for advisory board

Example of case where both reactants are fully consumed:



Decision was made to show coefficient values of 1, but to remove the box around the coefficients. -Chris 11/19/09 11:42 AM

Put "reactant", "product" and "leftover" labels below appropriate histogram bars, delineate with a horizontal bracket. -Chris 11/19/09 11:43 AM

3rd tab: Game!

This game design was revamped at 11/19/09 design meeting. To see older version notes, look at historical versions of this Google doc. -Chris 11/20/09 4:39 PM
Have we considered including any "sandwich" problems to solve? I have a feeling that it might help some students. -pat loeblein 11/29/09 2:49 PM

Difficulty

Level is selected at the start of each game
The "degrees of freedom" are reaction complexity (#products), type of challenge, and whether images are shown
CM: the implementation will make it easy to change the definitions below

2 types of reactions:
I. those with 1 product
II. those with 2 products (more difficult than I)

2 types of challenges:
A. given the reactant quantities, guess the product and leftover quantities
B. given the product and leftover quantities, guess the reactant quantities (more difficult than A)

2 types of views:
1. show images = true; "curtain" is open
0. show images = false; "curtain" is closed (more difficult than 1)

3 levels of difficulty:

1	100% type I	75% type A, 25% type B	100% type 1, 0% type 0
2	50% type I, 50% type II	50% type A, 50% type B	75% type 1, 25% type 0
3	100% type II	25% type A, 75% type B	50% type 1, 50% type 0

Timing

Timer is optional, and is selected at the start of each game.
This timer may be an optional feature for research versions of this sim.
This design works equally well with and without the timer feature.

Scoring

Each game consists of 10 challenges.
The user is allowed 2 attempts at each challenge.

If correct on 1st attempt: 1 point
If correct on 2nd attempt: 0.5 point

Answering all challenges correctly on the 1st attempt will yield a perfect score of 10/10.
The score is presented as X/10, where X is the number of points received so far.

Interface

- Looks very much like the "Real Reaction" tab.

- Score and level controls appear at bottom of play area.
- Reactions are automatically selected based on level control setting, quantities are randomly generated.
- Reaction appears at the top, with an indication of how many challenges have been generated (eg, "Reaction 8")
- Editable spinners appear below the box (Before or After) that the user will be guessing.
- Instructions and buttons appear in the box above the editable spinners.
- Box where the guess is occurring is surrounded by "curtains". These curtains are typically open, showing the images in the box. At more difficult levels, the curtains will be closed, and will be opened only when the user answers correctly, or answers incorrectly on second attempt.
- A new game may be started at any time by pressing the "New Game" button. This cancels the game that is currently in progress; no summary of the canceled game is given.

We'll describe this interface via a user scenario, which will reference screen mockups. The scenario is for a type-A challenge; the scenario for type B-challenges is similar.

SCENARIO: Starting a game (Figure Game-1)
1. A dialog opens in the center of the screen. This dialog might be a separate window, or might be integrated into the play area; we can decide later. The dialog can be moved to reveal stuff behind it. The dialog is modal, nothing else in the play area can be used while it's open (the only thing usable in the play area is spinners, so this shouldn't be an issue.)
Since they must pick these settings before starting, I see no reason this has to be a separate dialog ... in fact you don't really want them to be able to "close" it because the have to start the game to move on. So I vote for having the graphic on the play area itself, and it would be great if it could be more more colorful and inviting than the standard controls. -Katherine Perkins 11/23/09 11:34 AM
2. The user selects a Level and whether they want a Timer.
3. Press the "Start!" button to start the game. If a timer was selected, the timer will start running immediately when Start! is pressed
4. Go to the "Presenting a challenge" scenario.
NOTE: When first entering this tab, there is nothing in the play area behind this dialog (or perhaps just empty Before and After boxes?). At the end of a game, the 10th challenge will be shown behind the dialog.
This seems fine to me, but would also be fine to blank out the screen when starting a new game and putting up this "game settings" screen. -Katherine Perkins 11/23/09 11:39 AM
I'll start with what Kathy suggests (blanking out the play area in all cases) since it's easier to implement. -Chris 11/23/09 11:02 AM

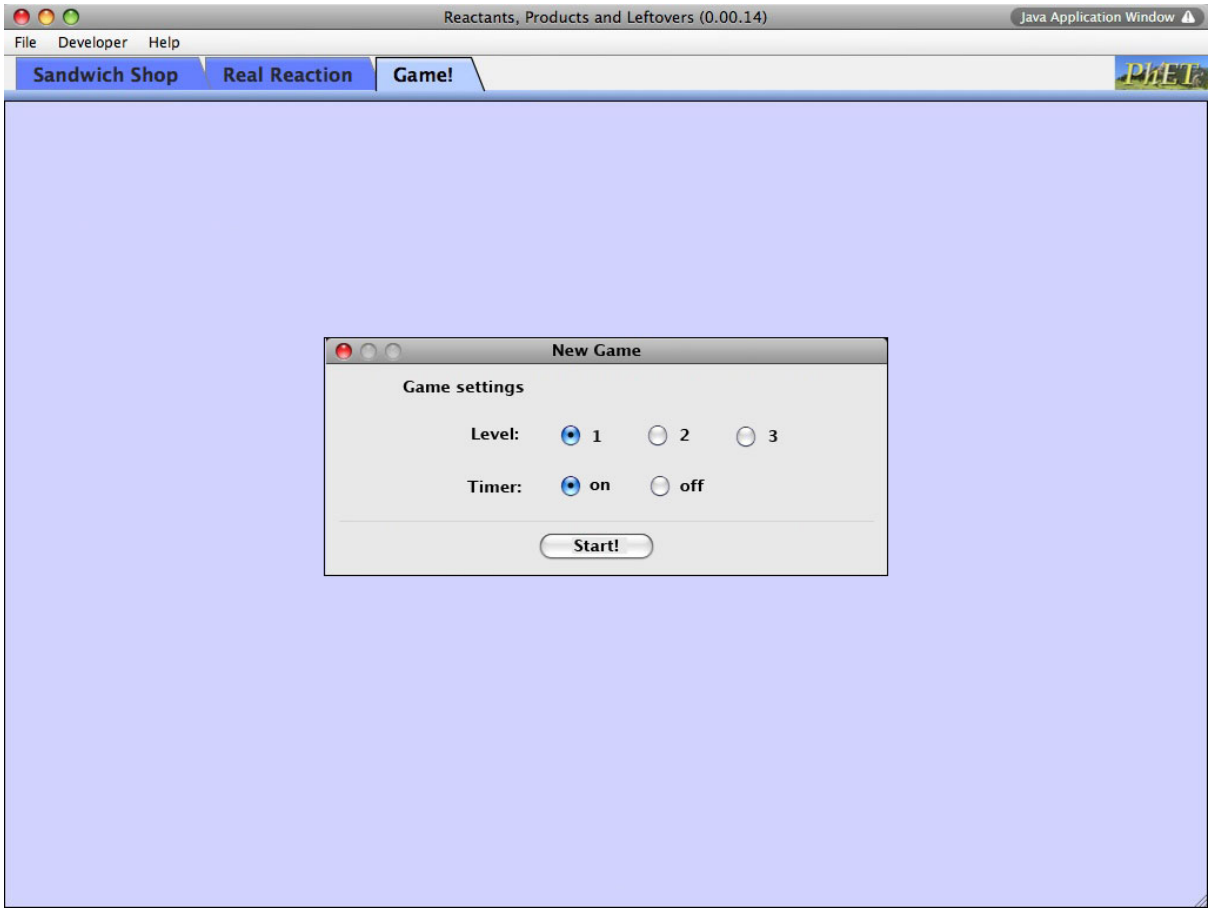


Figure Game-1

SCENARIO: Presenting a challenge (Figure Game-2)
1. A challenge is generated based on the Level control setting. Assuming that a type-A challenge is generated...
2. The curtains start closed, and "animate" open to reveal the challenge. For more difficult challenges, the curtains will remain closed, and the instructions and arrow will use a color that is easily visible on the curtain.
2. The Before box shows randomly-generated quantities of reactants. Reactant images are in the box, and below the box is a read-only histogram display showing reactant quantity values.
3. The After box has spinners below it, all set to zero. Instructions appear in the After box.
4. When the user changes any spinner, go to the "Answering a challenge" scenario.
Nice curtains! I like that the open to reveal the challenge. -Katherine Perkins 11/23/09 11:41 AM
Maybe the curtains could be black so they are not quite so eyecatching. Then once they move, people will see them when needed. -Wendy Adams 11/23/09 2:03 PM

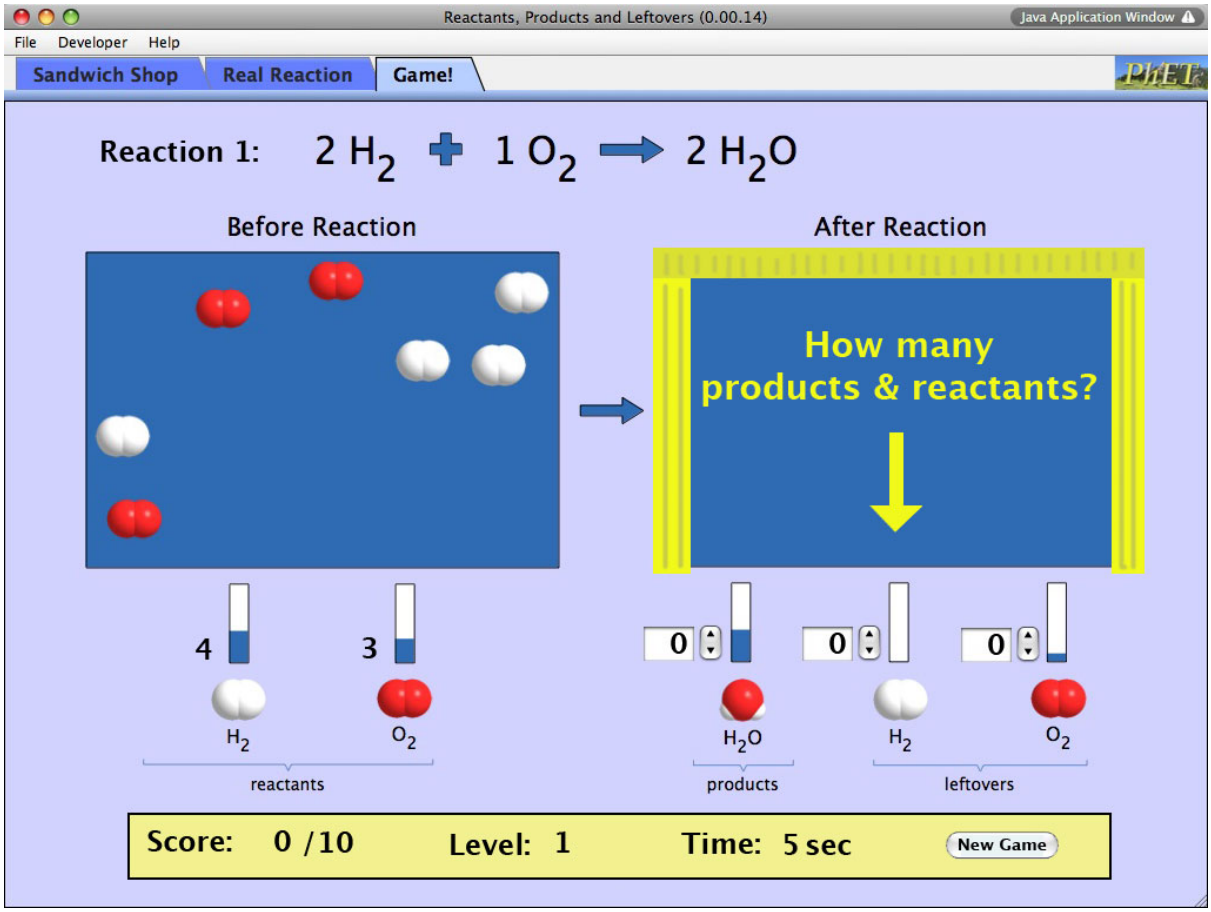


Figure Game-2

SCENARIO: Answering a challenge (Figure Game-3)
1. The instructions disappear, and images appear that match the quantity entered.
2. A button labeled "Check" appears at the bottom center of the box.
3. The user enters quantity values using the spinners. They can change values as often as they want.
4. When the user is done entering values, they press the "Check" button.

At first, I didn't see the "check" button , I wonder if it should be down by the "New Game" button pat loeblein 11/22/09 1:05 PM

If the answer is correct, go to the "Correct answer" scenario. If the answer is wrong and this is the first attempt, go to the "Wrong answer, first attempt" scenario. If the answer is wrong and this is the second attempt, go to the "Wrong answer, second attempt" scenario.

I think "check" will be OK where it is because it will dynamically appear and will draw your eye there when it does. -Katherine Perkins 11/23/09 11:42 AM

I'll start out by making the "Check" button larger and more eye-catching, and we can go from there. -Chris 11/23/09 10:59 AM

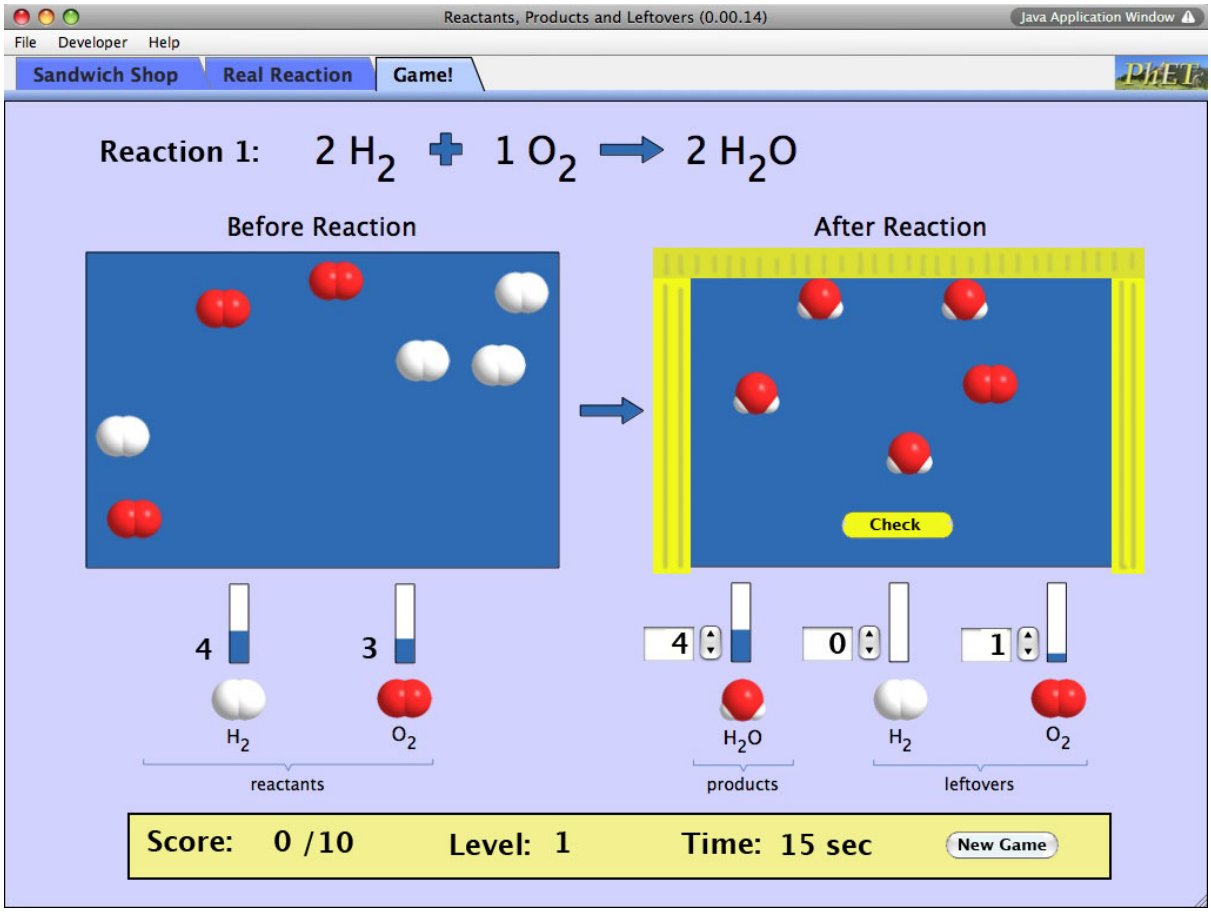


Figure Game-3

SCENARIO: Correct answer (Figure Game-4)
1. The quantities become uneditable.
2. A smiley face is superimposed on the top of the After box contents, to indicate success.
3. The number of correct guesses is incremented by 1 if this is the first attempt, 0.5 if this is the second attempt.
4. If this was challenge 1-9, a "Next" button appears. This allows the user to spend some time looking at what they did before going to the next challenge. Pressing "Next" goes to the "Presenting a challenge" scenario. As above, I didn't see the "Next" button and I think it would be better by "New game" button ? -pat loeblein 11/22/09 1:06 PM
Again, I think the dynamic of it will make a difference ... how about we interview and see if it is a problem. The students eyes will be on the box - that is where we want their eyes at least. -Katherine Perkins 11/23/09 11:43 AM
As with the "Check" button, I'll make the "Next" button larger and more eye-catching. -Chris 11/23/09 11:00 AM
You could make the face smaller and then you don't have to change the Next button. Also if you make the curtains a different color than the face and the next button, then the Next would show up better. -Wendy Adams 11/23/09 1:43 PM
5. If this was challenge 10, there is no "Next" button , and we immediate go to the "End of Game" scenario.

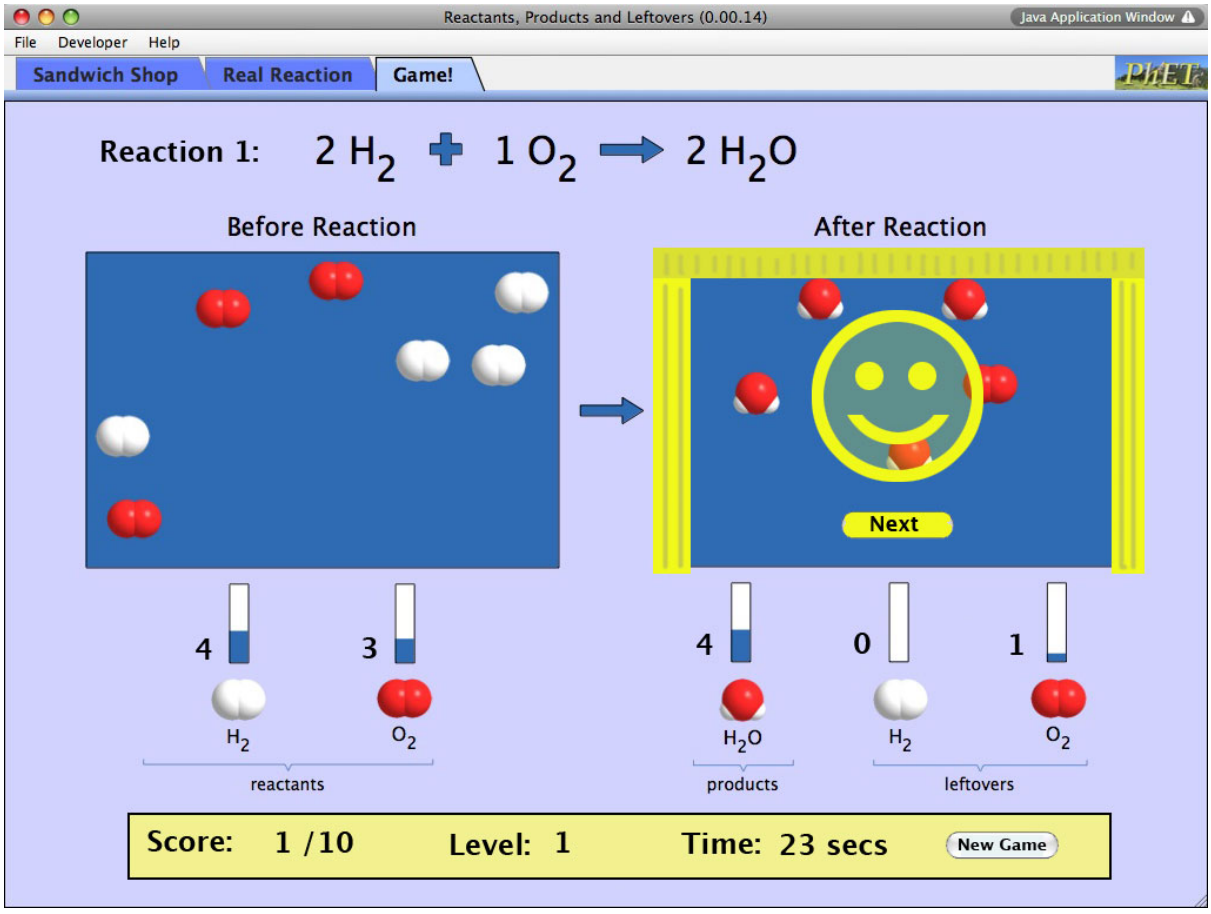


Figure Game-4

SCENARIO: Wrong answer, first attempt (Figure Game-5)
1. If the answer is wrong, a frowny face appears.
2. Spinners are replaced by read-only values.
3. No points are deducted from the score.
4. Pressing "Try Again" goes back to the "Answering a challenge" scenario.

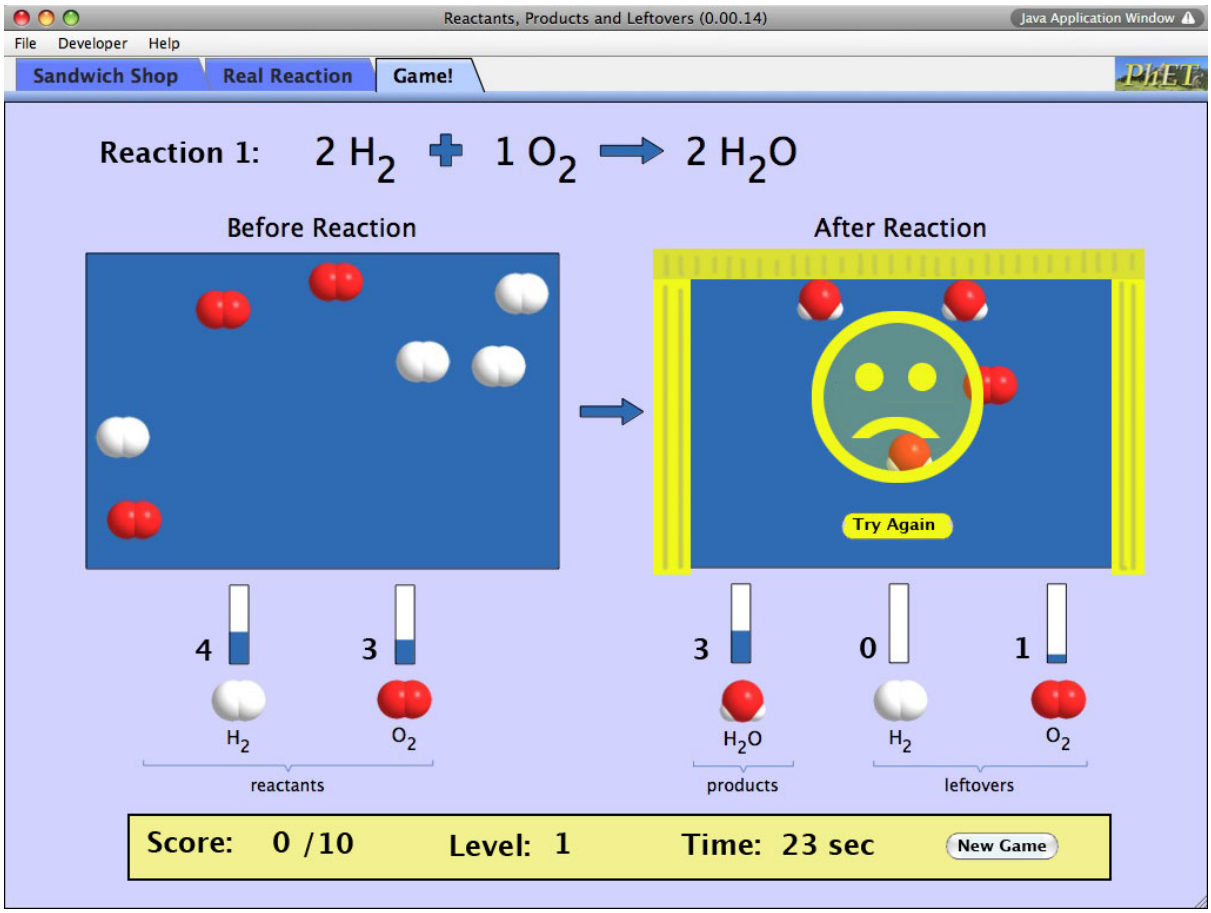


Figure Game-5

SCENARIO: Wrong answer, second attempt (Figure Game-6)
1. If the answer is wrong, a frowny face appears.
2. Spinners are replaced by read-only values.
3. No points are deducted from the score.
4. If this was challenge 1-9, a "Next" button appears. This allows the user to spend some time looking at what they did before going to the next challenge. Pressing "Next" goes to the "Presenting a challenge" scenario.
5. If this was challenge 10, there is no "Next" button, and we go immediately to the "End of Game" scenario.
I think we decided on a slightly different implementation for this scenario.
Keep showing the user's answer, but have 2 buttons side by side, one says "Show answer" one says "Next" ... if they click "show answer" then the correct answer appears and the only option for buttons left is "Next". -Katherine Perkins 11/23/09 11:45 AM
Kathy is correct (and so are my meeting notes, doh!) I'm not going to revise the mockup unless someone doesn't understand Kathy's description. -Chris 11/23/09 11:04 AM

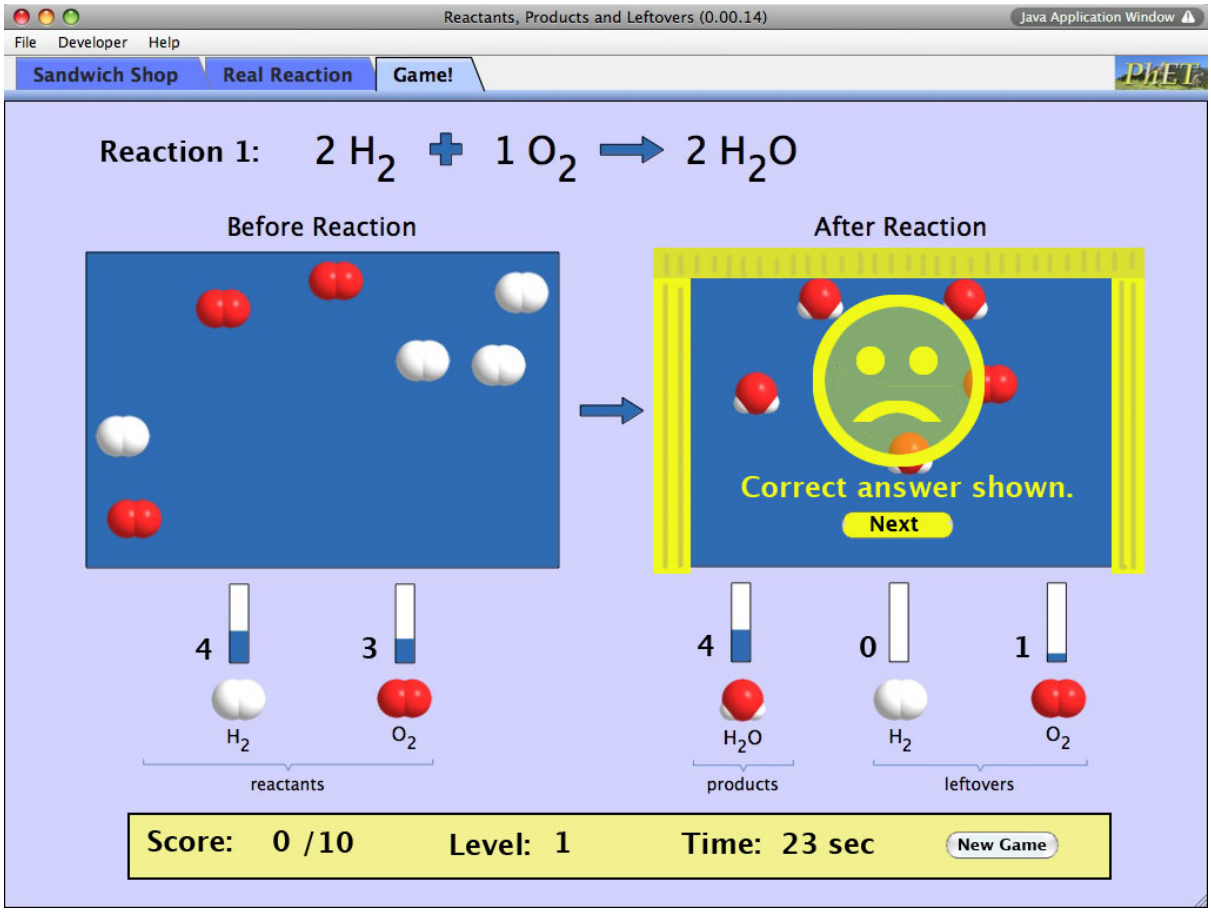
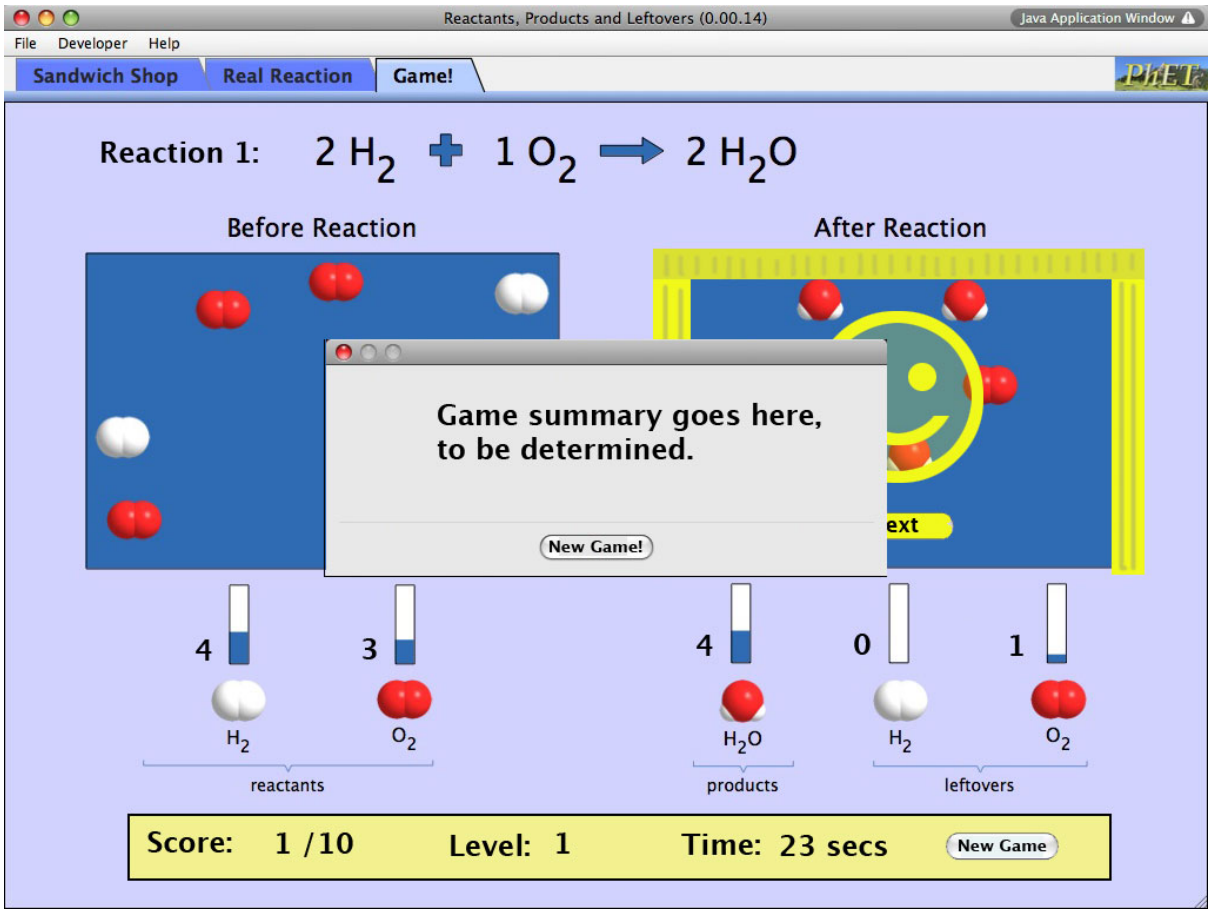


Figure Game-6

SCENARIO: End of Game (Figure Game-7)
1. If a timer was running, it stops.
2. A dialog opens showing a summary of the game results. This dialog may be a separate window, or it might be integrated into the play area; we can decide this later. This dialog can be moved to see the stuff behind it. This dialog is modal; nothing in the play area works while this dialog is open (this shouldn't be a problem, because at this point there's nothing that can be used in the play area, all spinners are now read-only.)
3. If the user got a perfect 10/10 score, the dialog shows a "reward" graphic, and says something like "You've mastered Level 1" (to encourage them to move to a higher level). good idea! -pat loeblein 11/22/09 1:13 PM
4. Pressing the "New Game" button goes to the "Starting a game" scenario.
Again it would be nice for dialog to have a more fun, colorful look than offered by the standard gray dialog. -Katherine Perkins 11/23/09 11:47 AM
For the mockups, I did what was fastest for controls. I'll be happy to spend as much time as you want on making things look more fun, but would prefer to get things working first with standard Swing controls, since they are essentially free. -Chris 11/23/09 11:05 AM



SCENARIO: Press the "New Game" button in the play area
If the "New Game" button is pressed in the play area, go immediately to the "Starting a game" scenario. No confirmation is requested, and no summary is given of the game that was in progress.

Chemical Equations

The equations only contain the elements:
H C N O F P S Cl
Why? Most abundant nonmetals.

The equations do not contain:
1. metals
2. ions (mono- or poly-atomic)
Why? So that the molecular images could be drawn as space-filling models.

Of the 40 equations below:
1. Approx half contain 1 product
2. The other half contain 2 products

$2H_2 + O_2 \rightarrow 2H_2O$
$H_2 + F_2 \rightarrow 2HF$
$H_2 + Cl_2 \rightarrow 2HCl$

$CO + 2H_2 \rightarrow CH_3OH$
$CH_2O + H_2 \rightarrow CH_3OH$
$C_2H_4 + H_2 \rightarrow C_2H_6$
$C_2H_2 + 2H_2 \rightarrow C_2H_6$

$2C + 2H_2O \rightarrow CH_4 + CO_2$
$CH_4 + H_2O \rightarrow 3H_2 + CO$

$C + O_2 \rightarrow CO_2$
$2C + O_2 \rightarrow 2CO$
$2CO + O_2 \rightarrow 2CO_2$
$C + CO_2 \rightarrow 2CO$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$
$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$
$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$
$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

$C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$

$C + 2S \rightarrow CS_2$
$CH_4 + 4S \rightarrow CS_2 + 2H_2S$
$CS_2 + 3O_2 \rightarrow CO_2 + 2SO_2$

$N_2 + 3H_2 \rightarrow 2NH_3$
$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$
$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
$4NH_3 + 7O_2 \rightarrow 4NO_2 + 6H_2O$
$4NH_3 + 6NO \rightarrow 5N_2 + 6H_2O$

$N_2 + O_2 \rightarrow 2NO$

$2NO + O_2 \rightarrow 2NO_2$
$2N_2 + O_2 \rightarrow 2N_2O$

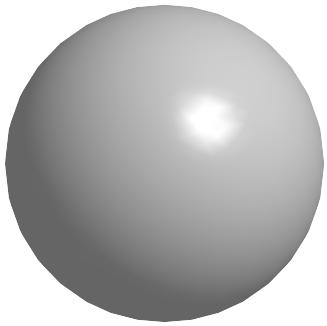
$P_4 + 6H_2 \rightarrow 4PH_3$
$P_4 + 6F_2 \rightarrow 4PF_3$
$P_4 + 6Cl_2 \rightarrow 4PCl_3$
$P_4 + 10Cl_2 \rightarrow 4PCl_5$
$PCl_3 + Cl_2 \rightarrow PCl_5$

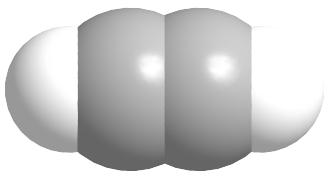
$SO_2 + 2H_2 \rightarrow S + 2H_2O$
$SO_2 + 3H_2 \rightarrow H_2S + 2H_2O$
$2SO_2 + O_2 \rightarrow 2SO_3$

$2F_2 + H_2O \rightarrow OF_2 + 2HF$
$OF_2 + H_2O \rightarrow O_2 + 2HF$

Images

The atoms are not the same size in each image!
This is because the program used to make the images fills the screen area for each atom/molecule.
Thus, the C atom below looks bigger than the C2H2 molecule below it.
Also, all diatomic molecules (H2, N2, O2, F2, Cl2) look the same size.
Since molecule shape/size is not a learning goal, we will simply watch for any misconceptions in interviews.
If need be, we can always resize the images.
If you try to resize the images so that the atoms have consistent sizes, I guarantee that we're going to run into screen layout problems. The user-interface design is based on the assumption that molecule images have similar sizes. So don't plan on being able to do this. If you think this is might be an issue, investigate it NOW. -Chris 12/8/09 11:03 AM
Robert Parsons commented:I think it's ok to have the atom sizes be inconsistent. These pictures are intended to be *schematic* representations of molecules, not realistic ones, and we want students to be able to deal with such representations since they will encounter them elsewhere, for example in textbooks.





Online Resources

1. $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$
http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/limitr15.swf
Animation of gas molecules with superfluous male narrator. **By far the most popular.**

2. $N_2(g) + O_2(g) \rightarrow 2NO(g)$
http://www.deciencias.net/proyectos/0cientificos/Tiger/paginas/LimitingReactant.html
Animation of gas molecules. Reaction very slow.

3. $C_xH_y(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$
http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/stoichiometry/stoic_select_both.html
Simulation with some feedback to user, but non-intuitive interface design. Reaction hard to follow, and not very clear how sim relates to concept.

4. $2NH_3 + CO_2 \rightarrow (NH_2)_2CO + H_2O$
http://ir.chem.cmu.edu/applets/stoich.php
Interactive bar graph of reactant and product amounts, but only shows one case.

5. $Zn(s) + 2HCl(l) \rightarrow ZnCl_2(l) + H_2(g)$
http://cwx.prenhall.com/petrucci/medialib/media_portfolio/text_images/015_LIMITREAGENT.MOV
Movie with female narrator. Very traditional, but does show states other than gas.

6. Bl + 2Nt → BlNt2
http://faculty.washington.edu/dwoodman/LimitingReagent/dswmedia/limitingReagent.html
Tutorial uses nuts ("nuttigen") and bolts ("boltium") to illustrate concept. Little interaction or animation, mostly male voice instruction.

7. 2 bread + 1 cheese + 1 meat → 1 sandwich
http://www.gautamsaha.com/file.php/7/limiting_reactant.swf
Click and drag to make a sandwich. Loud voice says "nice" on each drag. Nice interface, but error in function.

References

1. Nurrenbern, S.C.; Pickering, M. *J. Chem. Educ.* **1987**, *64*, 508-510.
Title: Concept Learning versus Problem Solving: Is There a Difference?

2. Sawrey, B.A. *J. Chem. Educ.* **1990**, *67*, 253-254.
Title: Concept Learning versus Problem Solving: Revisited

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Research Ideas

1. Interview: Can remove 2nd "microscopic" tab and see if students can still understand analogy

2. Recitation: General chemistry course at CU uses recitation material that follows the same sequence: 1. analogy, 2. microscopic representation; 3. traditional symbolic problem; can see if simulation (vs. written instruction) promotes more engagement, better learning

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Meetings

9/4/09
Kathy, Jack, Kelly
Let's do limiting reagent sim!

9/15/09
Kathy, Noah P, Robert, Kelly
Need to make sim more interactive - change click-and-drag to sliders, pull-down menu to spinners

9/17/09 part 1
Trish, Kelly
Need to refine learning goals

9/17/09 part 2
Kathy, Trish, Noah P, Kelly
Sim needs new name - concept larger than limiting reagent
Will students fully explore 1st tab? Need to interview.

9/22/09
Kathy, Noah P, Robert, Kelly
No need for motion in 2nd & 3rd tabs

9/25/09
Kelly, Noah P, Chris, (Kathy briefly)
Chris' comments, emailed to the team after the meeting:

Choose one representation for spinners. Best would be to use an actual spinner, so you can be convinced that it really works in the formula interface. Next best would be to use the representation in the design doc that has up-&-down arrows.

I asked why we're using sliders instead of spinners to set quantities in the boxes. The answer is that the sliders are supposed to serve as both a value control and a sort of histogram representation. There are several problems here. First, I think it's a bad idea to use a permanently-disabled slider for this purpose below the Products box, users will always be wondering when it will become enabled and it's a bad use of this control. Second, I don't recommend trying to overload Swing sliders as histograms, it will be a nightmare to make them line up. It would be better to create our own histogram widget, a vertical bar (much like a slider's track) that fills up with a color based on the value (sort of like a rectangular thermometer). The widget under the Reactants box would have a handle (similar to a slider knob) that lets you increase/decrease the histogram value. The widget under the Products box would look the same, but without the knob. If the "histogram widget" idea doesn't work for you, then consider separating the value control from the histogram representation (Kelly, this is what we started to sketch out on the blackboard.)

Having radio buttons for selecting coefficients or subscripts creates a usability problem. If (like Kathy) you intend to set all of your coefficients first, then all of your subscripts, you have to click one radio button. But (if like me, and I suspect many others) you work left-to-right and configure each term, then you have to click radio buttons many times. It's not worth arguing over which way of using the interface is correct; the point is that both ways are equally valid (and possible!), and this user interface makes one of those approaches a royal pain. Also consider the accessibility issues for disabled users. Kathy mentioned that removing these radio buttons would make the interface more complicated, but I don't see how that is the case; both the coefficient and subscript controls are always visible, the radio buttons simply control which ones are editable. So I think we should ditch the radio buttons, and allow simultaneous editing of coefficients and subscripts.

The boxes show reactants and products. Is there any need to represent "left overs"? For example, suppose my formula for a sandwich is "2 bread + 1 cheese + 1 turkey". I put 2 bread, 1 cheese, and 1 turkey in my "Reactants" box, and I see 1 sandwich in my "Products" box. Now suppose I increase cheese to 3. I have 2 left-over pieces of cheese, but those left-overs aren't shown or represented anywhere. In fact, I can change the quantity of cheese all day long, and (other than the cheese quantity control) nothing in the sim will change. I don't know if this is an issue, but I thought I should bring it up.
Kelly pointed out that left-overs do appear in the Products box, as shown in the sandwich screenshot. And I see left-overs in other screenshots, too. Do we need to include the left-overs in the histogram below the Products box? - cmalley@pixelzoom.com 9/24/09 6:28 PM
We did decide to show leftovers below the After box. -Chris 11/19/09 11:48 AM

9/28/09
Kathy, Kelly
Will NOT show leftovers in histogram below "after reaction" box - may cause visual overload

Lots of meeting notes missing between 9/28/09 and 11/19/09. -Chris 11/19/09 11:36 AM

11/16/09
Chris, Kelly
Game design meeting

11/19/09
Kathy, Wendy, Robert, Trish, Chris, Kelly
Game design meeting