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Lesson overview

Subject:	Chemistry
Grade:	10 -12
Topic:	Stoichiometry
Concepts:	Stoichiometric Conversions
Essential questions:	How do we quantify changes in systems?

Objectives

✓ Students will know:

1K) Dimensional analysis is a way of translating a measurement from one unit to another unit.
2K) Atoms and molecules are too small to count by usual means.
3K) Stoichiometry involves quantitative relationships.
4K) Stoichiometric relationships are based on mole quantities in a balanced equation. These are represented by coefficients.
5K) A coefficient is a quantity that precedes a reactant or product symbol or formula in a chemical equation and indicates the relative number of particles involved in the reaction.

✓ Students will understand that:

1U) conservation of matter is represented in balanced chemical equations.
2U) changes are quantified in chemical reactions.

✓ Students will be able to do:

1D) Calculate mole ratios.
2D) Make calculations involving relationships between: mole-mole; mass-mass; mole-mass.
3D) Define limiting reactant, excess reactant, and theoretical yield.

**Checking points*.

- Do the "Know" objectives cover the essential information to be learned?
- Are the "Understand" objectives big and transferable ideas of the discipline?
- Are the "Do" objectives are observable and measurable? Do they encompass essential skills?
- Do the KUDs "fit together"-in other words, will they come together coherently?

Who: s. in this class vary in their mathematical reasoning and also in their ability to visualize abstract concepts. Preassessment would be used to indicate the degree to which s. 1) how to calculate the number of moles present in the mass of a substance (this should be prior knowledge), 2) how to set up a dimensional analysis problem (this should be prior knowledge and will be extended in this unit), 3) how to write balanced chemical equations (this should be prior knowledge), 4) understand the relationship between two coefficients in a balanced equation.

This lesson would come at the beginning of a unit on stoichiometry, following a unit on writing chemical formulas, writing chemical equations, and balancing equations. A preassessment (above) would be given prior to this lesson to determine in which tier s. belong.

Introduction

Beginning today, for the next few weeks, we're going to work on applying our understanding of chemical reactions and moles.

Q: What is a mole? (EA: quantity that allows us to "count" things that are too small to count by usual means, or lets us convert between different types of measurements, L, molecules, mass, etc – prior knowledge)

T: So moles let us convert between different units of measurement. They also let us convert between different types of substances, so long as we have the balanced equation.

We're going to start this unit by gathering some data from an experiment, then, we're going to use that data we collect to work towards understanding how balanced chemical equations can help us determine and convert between chemical quantities.

Body of Lesson (differentiated based on readiness)

All students complete an experiment to gather data. These experiments vary based on s. readiness to apply prior process skills to a new situation and also based on s. visualization abilities (learning profile differentiation). The readiness differentiation is more important in this case:

Tiers 1, 2: Combust magnesium into magnesium oxide.
Tiers 3, 4: Create a "chemical reaction" for the formation of s'mores using chocolate, graham crackers, and marshmallows.
*See reflection as to why I chose two different labs.

Tier 1

These s. have all of the background knowledge and mathematical skills required to do stoichiometry problems. (Preassessment shows they have a working understanding of 1-3 and some understanding of 4) They can probably figure out how the relationship and how to apply the math on their own with little scaffolding then extend this to limiting reactants (will be covered more directly by s. in other tiers in subsequent lessons.) They are at close to mastery level with this material already and will probably work on "AP level" work for the rest of the unit.

S. are presented with the problem: *How many moles of magnesium oxide are produced in the combustion of magnesium? Theoretically, how many moles of magnesium oxide could be produced in this reaction?*
S. are given a procedure to complete the experiment and are told what data to collect, but they are not

given a data table.
S. write a balanced chemical equation for the combustion reaction.

S. use their data (mass of Mg before reaction and mass of MgO after reaction) to answer the questions and justify their answers mathematically:
1) "Theoretically, how much MgO **could** have been formed in the reaction in mass? in moles? in molecules?" (requires the balanced equation, conversions from initial mass Mg to various quantities of MgO. These conversions were learned by s. in a different context during a previous unit.)
2) "Which reactant limits the amount of MgO that can be produced? Why?" (requires conceptual understanding that there is an unlimited amount of O_2)
*3) As a percentage, express the amount of MgO formed relative to the theoretical amount of MgO that could be formed.

*This is not a direct objectives for this lesson, but would naturally extend the discussion. I included it for this tier since they are so advanced in their conceptualization of the mathematics involved in stoichiometry. These concepts will be taught to s. in the other tiers in later lessons using their experiments from this lesson as examples, but in a more directed manner.

Tier 2

These s. have all of the background knowledge and mathematical skills required to do stoichiometry problems. (Preassessment shows they have a working understanding of 1-3 and have no idea of the relationship in 4)

S. are presented with the problem: *How many moles of magnesium oxide are produced in the combustion of magnesium? Theoretically, how many moles of magnesium oxide could be produced in this reaction?*
S. are given a procedure to complete the experiment and are told what data to collect, but they are not given a data table.
S. complete the experiment.
S. write a balanced chemical equation for the combustion reaction
S. use their data (mass of Mg before reaction and mass of MgO after reaction) to answer the questions and justify their answers mathematically:
1) "How much MgO should have been formed in the reaction in mass? in moles? in molecules?" (requires the balanced equation, conversions from initial mass Mg to various quantities of MgO)
Scaffolding questions for this tier:
What is the ratio of mols Mg and mols MgO given in the balanced equation you wrote above? EA: 2:2
What is the relationship between moles O2 and moles MgO from the balanced equation above? EA: 1:2
How many moles of Mg did you start with? (Hint: Convert from g Mg to moles of Mg. What information do you need? (EA: molar mass – prior knowledge)
How many moles of MgO is equal to the number of moles you calculated above? (Hint: Use the ratio of moles Mg and moles MgO you found above.)
How many grams of MgO are equal to this number of moles of MgO? What information do you need to solve this? (EA: molar mass – prior knowledge)
This is the theoretical yield, or the amount of MgO that it is possible to produce from your beginning mass of Mg.
How many different conversions did you use? (EA: 3)

Is there a way you could set this up that is similar to the bridge notation we used in dimensional analysis? First, try setting it up starting with g Mg and converting to moles MgO (Check: Do all of your units cancel? Do you get the same answer for the number of moles as you did above?) How would you set it up if you wanted to convert from g Mg to moles MgO? What's the difference between these two set ups?
What would be different if you wanted to convert from mass Mg to molecules of MgO? (EA: You'd switch out mass MgO and the molar mass conversion to molecules MgO and Avogadro's number as the conversion.)
Do this. What do you get? How could you check your answer? (start with moles MgO calculated above and only do the 1-step conversion.)

2) "Which reactant limits the amount of MgO that can be produced? Why?" (requires conceptual understanding that there is an unlimited amount of O_2)

Tier 3

These s. have all of the background knowledge and a conceptual understanding of how to balance equations but are lacking in the mathematical skills required to do stoichiometry problems. (Preassessment shows they have a working understanding of 3 but difficulty with 1 and 2, and no idea of 4)

S. are presented with the problem: *A s'more is made from 4 Mm (minimarshmallows), 2 Cb (chocolate bars), and 2 Gc (Graham Crackers). Given your supplies, make as many s'mores as you can.*
S. complete the experiment.
S. write a balanced chemical equation for the "reaction" for the formation of the s'more.

S. answer the following questions:
1)Based on your balanced equation, what is the ratio of Mm to Smores? Gc to Smores? Cb to Smores? Mm to Gc? Mm to Cb? Gc to Cb?
2) How many "moles" of S'mores can you make with your reactants?(EA: 2) This is your theoretical yield of s'mores.
3) What do you need more of to make another s'more? (EA: chocolate.) What do you have left over? (EA: Gc) What did you have just enough of? (EA: Mm)
The thing you had left over is the excess reagent. The thing you didn't have enough of is the limiting reactant.
4) How many moles of Mm would you need to make 3 s'mores? Set up a mathematical expression to show how you figured this out. (Hint: try setting it up as a DA problem like we did earlier in the year.) (practicing using mole ratios)
5) How many moles of Gc would you need to make 5 s'mores? Set up a mathematical expression to show how you figured this out. (Hint: try setting it up as a DA problem like we did earlier in the year.) (practicing using mole ratios)
6) How does the moles of Gc relate to the number of s'mores you make? (EA: By the ratio in the balanced equation.)
7a) Assuming the molar mass of Gc is 100g/mole, and you have 250g of Gc, how many moles of Gc do you start with? (Hint: Convert from g Gc to moles of Gc.) Assuming you had enough of everything else (Cb and Mm)
7b)How many moles of s'mores could you make? (Hint: Convert from moles Gc to moles S'mores.)
7c) How many different conversions did you use? (EA: 2, g→ mole, mole→ mole)

7d) Is there a way you could set this up that is similar to the bridge notation we used in dimensional analysis? First, try setting it up starting with g Gc and converting to moles s'more (Check: Do all of your units cancel? Do you get the same answer for the number of moles of s'mores as you did above?)
8a) What would be different if you wanted to convert from mass Gc to molecules of s'mores? (EA: You'd switch out mass s'mores and the molar mass conversion to molecules s'mores and Avogadro's number as the conversion.)
8b) Do this. What do you get? How could you check your answer? (Hint: start with moles s'mores calculated above and only do the 1-step conversion.)

Tier 4

These s. are lacking in the mathematical skills and conceptual knowledge required to do stoichiometry problems. They may or may not remember how to balance equations, but cannot do so consistently.

Same as tier 3 with the following scaffolding:
These s. will check their balanced equation, mole ratios with the t. as they work through the problems. Additionally, the t. will work with these s. directly as a small group to help them recall how to set up a DA problem.
T. will monitor these s. more closely and the lab will be conducted in a more direct instruction manner with respect to the calculations. (T. will walk them through the DA set up, though the questions are the same as tier 3.)

Closure

After all groups have finished their activities and the associated questions, the t. brings them together as a group.
Q: How can you find the relationship between the moles of a reactant and the moles of a product? (EA: mole ratio from the balanced equation)
Q: What quantity are you determining if you're finding the maximum amount of moles that a specific mass of a substance can make? (EA: Theoretical yield)
Q: What do we call the substance that causes a reaction to not produce more products? (EA: Limiting reactant)
Q: If you were given a mass of a reactant and wanted to determine the number of moles of product that could be made, what would you do? (EA: set up a conversion from mass → mole using MM, then from mole reactant → mole product using the coefficients (mole ratios) from the balanced equation.)