**Lesson Plan: Lecture 7**

**Limiting Reagent, Yield, and Atom Economy**

**Description**

In this lecture, students will be introduced to the concepts of limiting reagents, yield, and atom economy. Building upon their working knowledge of balancing equations and stoichiometry, students will apply those core skills to determine the efficiency of reactions based upon molecular factors. This lecture will focus on the fundamental ways molecules are evaluated on their efficacy and extrapolate to the Green Chemistry metrics. Since the majority of the content in this lecture focuses on organic molecules and their functional groups, it is important that student have these skills reinforced by continuing to name and draw organic structures when performing calculations.

**Prior to Lecture**

Lecture Readings (Optional):

* Giraud, R., Williams, P., Sehgal, A., Ponnusamy, E., Phillips, A., Manley, J. “Implementing Green Chemistry in Chemical Manufacturing: A Survey Report”; *ACS Sustainable Chemistry & Engineering;* 2014, *2* (10), 2237-2242. (optional) <https://pubs.acs.org/doi/abs/10.1021/sc500427d>
* Mastronardi, M., Reyes, L. “Green Chemistry Principle #2: Atom Economy”; 2014, at GreenChemofT.wordpress.com.

<https://greenchemuoft.wordpress.com/2014/04/04/greenchemprinciple2/>

Videos:

* [Yield and Limiting Reagent](https://www.youtube.com/watch?v=U5UTb9c78vE)
* [Theoretical Yield](https://www.youtube.com/watch?v=3QNKmMNO5wA)
* [Percent Yield](https://www.youtube.com/watch?v=pFmCn-cwOW8)
* [Quick Snapshot of Atom Economy](https://www.youtube.com/watch?v=Zuyk4hfbjSA)
* [Atom Economy](https://www.youtube.com/watch?v=Y9NVz7_9zw4)

**Topics to Cover in Lecture**

* Limiting reagents
  + Emphasize stoichiometry and balancing equations from previous class lectures.
* Theoretical Yield
* Percent Yield
* Atom Economy
* E-Factor

**Class Exercise**

* Greener Synthesis of Ibuprofen: this activity is included on slide 26.
  + Students look at two synthetic routes to ibuprofen and calculate the atom economy. Use the Class Exercise hand-out titled “Greener Synthesis of Ibuprofen”.
* An alternative class exercise is included at the end of the presentation where the instructor can compare two ways of making titanium dioxide (TiO2) white pigment. This provides the instructor an option for analyzing an inorganic reaction process and providing students with practice in balancing equations, calculating molecular weights, and calculating atom economy.

**Homework**

* Stoichiometry and Reactions

**Supplementary Materials**

* The EcoScale as a Framework for Undergraduate Green Chemistry Teaching
  + Reference: Dicks, A.P., Hent, A., Koroluk, K.J., Green Chemistry Letters and Reviews, 2018, 11:1, 29-35, <https://www.tandfonline.com/doi/full/10.1080/17518253.2018.1431313>
  + The instructor can explore metrics further with students if there is interest and time. This included open-access manuscript provides a framework for analyzing chemical reactions through a new metric that combines many green chemistry metrics, including atom economy.