Inspiration for this activity came from Beyond Benign:

https://www.beyondbenign.org/k12/

Teacher Instructions and Materials

Instructions:

- Distribute the 12 Principles Match-up student handout and read the background information to students.
- Instruct students to get into groups and read through the "untranslated" principles together. Once groups are done reading, they will obtain a set of 24 cards, 12 pink and 12 yellow. Their objective is to match each pink card to a yellow card to form complete sentences that simplify the 12 Principles. When their group has finished matching up the cards, they must get their work checked before moving on to the next step, which is to record the complete sentences in the table in part 2 of the student handout. Finally, they must write a real-life example that illustrates each principle.
- Review simplified principles and examples when all groups have finished.

Common Misconceptions and Stumbling Blocks:

- Many students will think of recycling as an example for principles 1 and/or 7. This is not the best example for either one. Some recycling methods, such as the US exporting their recycling to other countries like China, still result in waste. Also, most recycling is done on an open-loop basis, so the material being recycled - for example, plastic in a water bottle - is not being used to make more plastic water bottles.
- Students may get hung up on principles 2 and 8 because they talk about atoms and molecules. Remind those students that their example doesn't necessarily have to do with chemistry, and that substituting the word "ingredient" may spark more thoughts.
- Students may have trouble thinking of examples for principle 9. Teacher guidance may be necessary.
- See Answer key below:

	Simple Version	Example (many possible answers)
1. **Prevention.**	Prevent waste.	Eat leftovers instead of throwing food away.
2. **Atom Economy.**	Incorporate all the atoms into the final product.	When baking, measure out only what you need so there is no unused flour, sugar, etc.
3. **Less Hazardous Chemical Synthesis.**	No toxic ingredients.	Lead should not be found in drinking water.
4. **Designing Safer Chemicals.**	Make safe products that work just as well as products that do not follow the 12 Principles of Green Chemistry.	Safer peroxide bleach should work just as well as traditional chlorine bleach.
5. **Safer Solvents & Auxiliaries.**	Don't use ingredients that are not essential.	Buy unscented laundry detergent and soap.
6. **Design for Energy Efficiency.**	Reduce energy usage by running experiments at room temperature.	Wash laundry in cold water.

7. **Use of Renewable Feedstocks.**	Use materials that are renewable.	Breaking down old aluminum cans to make new ones.
8. **Reduce Derivatives.**	Let the atoms and molecules be what they want to be. Don't try to change their natural properties.	Don't engage in peer pressure or bullying.
9. **Catalysis.**	Use a reusable method to speed up a reaction.	When boiling water for pasta, put a lid on the pot so the heat is trapped and it boils faster.
10. **Design for Degradation.**	Use materials that will break down in the environment.	Use paper straws instead of plastic ones.
11. **Real-time Analysis for Pollution Prevention.**	Pay attention to your experiment and collect data as it is happening. That way you won't mess it up.	When cooking, make sure you're following the recipe.
12. **Inherently Safer Chemistry for Accident Prevention.**	Safety first.	Don't text and drive.

Materials: Make enough copies of these cards for all groups to have one set. Cut cards out and shuffle before distributing to students.

Principle Part 1	Principle Part 2
1. Prevent	**waste**
2. Incorporate all the atoms into	**the final product**
3. No	**toxic ingredients**
4. Make safe products that	**work as well as products that do not adhere to the 12 Principles of Green Chemistry**

5. Don’t use	**Ingredients that are not essential**
6. Reduce energy usage by	**running experiments at room temperature**
7. Use materials that are	**renewable.**
8. Let the atoms & molecules be what	**they want to be. Don’t try to change their natural properties.**

9. Make use of a reusable method to		**speed up a reaction**
10. Make products that will		**break down into safe substances after we finish using them.**
11. Pay attention to your chemical reaction and collect data		**while it is happening. That way, you won't mess it up.**
12. Safety		**first**