Green Chemistry Bingo

Objective

To help students learn about the principles of green chemistry.

Materials

Bingo cards, principles of green chemistry scenarios, bingo chips.

Detailed Description

Students will work in teams of two to three to play a group game of Green Chemistry Bingo. As scenarios are described students will place a bingo chip on ALL Principles of Green Chemistry related to that scenario. The first student/group to get "Bingo" wins.

Example Green Chemistry Bingo Card

Green Chemistry Bingo Card				
1	2	3	4	5
6	7	8	9	10
11	12	Free	12	11
10	9	8	7	6
5	4	3	2	1

Version A

During the game the teacher will read from a list of scenarios and the students must decide which principle of green chemistry is appropriate. This should happen as a class (ideally through a short discussion). In several cases multiple green chemistry principles may be appropriate and all that are identified can be "claimed" by the students.

Prior to the game, the class can decide when bingo is achieved (one line covered, two lines covered, two lines crossing in a X, the outside square of the card, etc.).

Version B

In this version, students are asked to come up with their own scenarios for the Green Chemistry Bingo that they then add to the mix.

The remaining rules are similar to that of version A.

12 Principles of Green Chemistry

Principle Number	Principle of Green Chemistry Official Language	Principle of Green Chemistry Everyday Language
1	Prevention It is better to prevent waste than to treat or clean up waste after it has been created.	It is better not to make a mess than to have to clean it up.
2	Less Hazardous Chemical Syntheses Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.	Use ingredients, or input materials, that are safe and good for/harmless to the environment.
3	Designing Safer Chemicals Chemical products should be designed to affect their desired function while minimizing their toxicity.	When designing new chemicals or materials, make sure they are safe.
4	Safer Solvents and Auxiliaries The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.	If you need to mix everything in a liquid to make your new chemical or material, make sure that liquid is not harmful. When possible, use water.
5	Real-Time Analysis for Pollution Prevention Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.	Develop tools and instruments to measure pollution and waste AS IT IS MADE (real-time) instead of having to take samples to the lab to test later.
6	Inherently Safer Chemistry for Accident Prevention Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.	Use ingredients, or input materials, and recipes, or chemical processes, that are safe and less likely to cause an accident.
7	Atom Economy Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product	Try to make all the different ingredients you have all useful, so you don't have to throw them away.
8	Design for Energy Efficiency Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.	Deign new chemicals or materials that can be made under *mild* conditions, for example, at room temperature (versus very high or very low temperature) or at normal pressure (versus high or low pressure).

9	**Catalysis** Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.	If you need to use an ingredient, or input, that you will end up throwing away, design your process and choose an ingredient of which you will only need to use a little bit.
10	**Design for Degradation** Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.	Design new materials and chemicals that are compostable and biodegradable.
11	**Reduce Derivatives** Unnecessary derivatization (use of blocking groups, protection/deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.	When possible, use simple ingredients, input chemicals, and ways to make things.
12	**Use of Renewable Feedstocks** A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.	Use input materials that are renewable, i.e., that can be quickly replaced. One example is bamboo. Another example is hemp.

Green Chemistry Bingo Chemical Scenarios

Scenario	Related Principles of Green Chemistry*
The more environmentally friendly soaps Christoph is developing at Sironix Renewables	3
The fabric recycling process Stacy and Cristo are developing at Evrnu	2, 8, 1
The new epoxy resin Jason and Jared are developing at ZilaWorks	3, 6, 1
The new flower foam Mikey is developing at Floral Soil Solutions	3, 10
The work Marty did with companies to replace harmful chemicals they were using	4, 6
A company that learns how to make 10 kg of medicine out of a recipe that had only been producing 10 g of medicine	7
Making T-shirts out of fast-growing bamboo plants instead of polyester	12
Running a reaction or making a product in water instead of oil	4
Developing packaging material that is biodegradable or compostable (like Ecovative) to replace Styrofoam or bubble wrap	10, 12
The development of new sensors that help you measure the current air quality	5
The new wallets they are making at Tidal Vison using waste salmon skin and crustacean (like crabs and lobsters) shells	12
The safer chemicals for floors being developed at Diatomix	3
All the companies trying to develop leather out of crop waste (you can read more about them here: https://www.entrepreneur.com/article/299459)	12

Developing thermometers that use alcohol instead of mercury (mercury can be very harmful to humans, plants, and animals)	3
Powering your home with energy from local sources instead of having to ship it across the world	8
Buying food that was made locally	8
Making a new material that just uses 2 steps instead of 10 steps	11
Riding your bike instead of driving your car	12
Developing the chemistry that won Yves Chauvin, Robert H. Grubbs, and Richard R. Schrock win the Noble prize in chemistry—they figured out how to make very challenging reactions run at lower energy conditions by adding a small amount of an extra ingredient that acts as a catalyst	8, 9
Running a reaction at room temperature instead of 1000° C	8

**Note: It is possible that your students may be able to identify connections between the scenario and a principle of green chemistry not listed here. That is great and should be encouraged as long as they can explain and justify their connection.*

As a bit of a twist on the discussion, you can also add in some non-green chemistry scenarios.