

E-Factor: Green Chemistry Crown



Steps, Content & Hints

Main directions and content for the activity are in the boxes to the left with the orange border, like this one.

In a classroom setting, you will lead the students through the activity with a series of questions, the students' own responses and brief explanations.

Whenever possible, find and affirm what's right about the students' answers.

Questions in Context:

Do you remember something better when you are asked to think about it?

On the right, in the conversation bubble outlined in yellow, are guiding questions that you should ask the students during the associated step.

Each question should be asked separately – and a short amount of time should be allowed for responses.

Green Chemistry Introduction: Defining Green Chemistry

Have students work in pairs for 30 seconds to come up with a definition for green chemistry. Break down the meaning of both words.

Establish that Chemistry is the science of making products.

Eco-friendly, good for the environment, sustainable.

What is green chemistry?
What is Chemistry? What does chemistry mean to you? Do you think of good things or bad things?

What does it mean to “go green”? Who has heard of companies going green? What does that mean?

What do Chemists do?

Use wait time . Build off of their prior knowledge. Acknowledge student responses and prompt them for more information. Control the conversation by asking for a certain number of answers.

Chemists are inventors. They help to design just about every product out there.

Traditionally chemists were not taught about the environmental impact or toxicology. We have had many advances and helpful inventions but we have also had inventions that have caused harm to the environment. Green chemists design products taking into account the entire process, energy efficiency, renewable resources, the product itself along with the end-of-life impact of the product.

Green chemistry is pollution prevention at the molecular level, the basic design stage. So what is it that green chemists do?

Is there anything in this room that a chemist invented? What about the desks, paint, floor, etc. Who has taken medicine? Does anyone use an iPod or an mp3 player? What about a computer or a cell phone?

Set the Scene: Connect the Dots & Introduce the Activity Topic

Connect the dots for them: they are the future scientists who will help to discover and invent the solutions to environmental challenges.

3 Criteria of Green Chemistry

Introduce the 3 criteria of green chemistry: safety, cost and performance

Would you buy a “traditional” cleaner that costs \$1 or a “green/safer” cleaner that costs \$5 for the same bottle size?

Would you buy a “traditional cleaner” that cleans well, or a “safer” cleaner that leaves streaks behind?

Green chemists think about safety, cost and performance in their product design.

Introduce Today's Experiment & Safety:

In this activity, we are working with safe materials which will not require you to wear gloves and safety glasses, but please practice safety when handling scissors and do not put small items in your mouth.

As green chemists, today you will make your own "Green Chemistry Crowns" and learn how scientists determine how wasteful a process is using the Environmental Impact Factor (E-Factor).

You will learn how to calculate the E-Factor of your crown making process.

E-Factor as a Green Chemistry Metric:

Throughout green chemistry, there are a number of ways to determine if one method of making a product is better than another. One such metric is called the E-Factor or the Environmental Impact Factor. The E-factor is the measure of the amount of a waste generated while making a product.

Define E-factor

$E\text{-factor} = \text{mass of waste} \div \text{mass of product}$

Introduce the phrase "The Goal is Zero"

As green chemists, we want to prevent waste.

By looking at the equation, can you tell if it is better for the E-factor to be a high number or a low number?

What is the goal with E-Factor? Why is an e-Efactor of zero best?

Manufacturing Processes

We have established that chemists make things. The process by which they make things is just as important to think about as the actual product that they make.

At the end of a process, you end up with your final product (what you intend to make), but waste is usually generated as well. As green chemists, we want to reduce or eliminate waste as much as possible, yet still make a good performing product (crown).

Let's get started making your green chemistry crown.

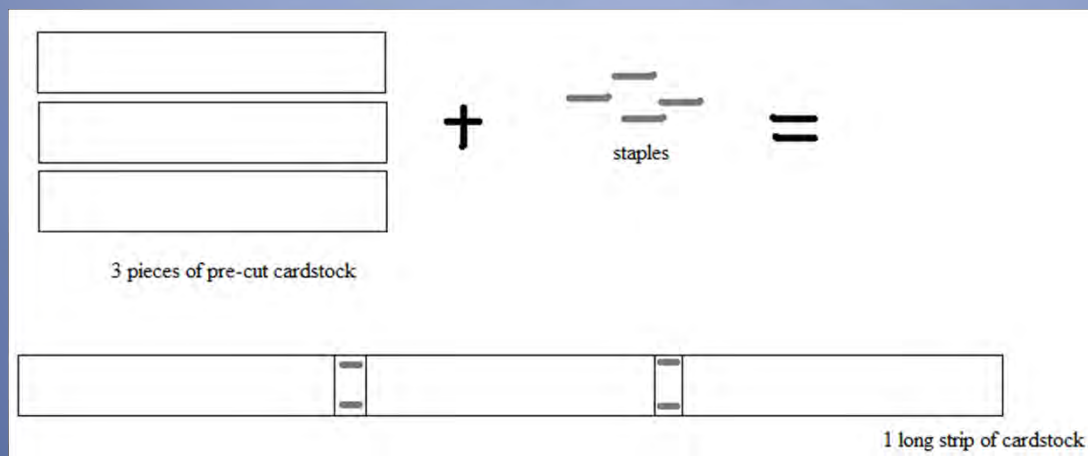
What does "manufacture" mean? What are some basic steps in a manufacturing process?

Besides how well the product performs, what are two other things that green chemists must consider?

What is the E-factor goal when making your crown?

1. Staple 3 pieces of pre-cut cardstock to make 1 long strip (slightly overlap the ends).

Staple the pieces together for younger students



2. Wrap the long strip around your head and determine how much of the strip is needed to make a crown.
3. Using scissors, cut off the extra part of the strip and set it aside in a waste pile.
4. Staple the ends of your long strip together to make the crown.

Help younger students measure the strip around their heads and cut the excess part of the strip off

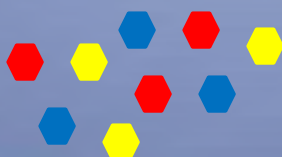


5. Using scissors, hole-punchers and markers, decorate your crown. Save all pieces of any cardstock that you cut out from your crown and set them aside in the waste pile.

Waste pile should have excess piece of long strip and cutouts from the crown strip



- Remove all jewels from the bag
- All green jewels can be placed on the crown.
All non-green jewels must go into the waste pile



Waste
Pile



- Using the scale, measure how much your final crown weighs.
- Measure how much your waste pile weighs.
- Calculate the e-factor of the crown making process by dividing mass of waste by mass of product.
- Discuss what your e-factor means in terms of your crown making process being wasteful or efficient.

How many grams does your crown weigh?
How many grams does your waste pile weigh?
How do you calculate e-factor?
What is the e-factor from your process?

Did you reach the goal of e-factor?
What does your e-factor tell you about your process?

- From your waste pile, pull out the non-green jewels (there should be 3 other colors)
- Separate the jewels by color into small piles



- Discuss one way that you can reduce waste in your crown making process.
- Write this down on your 3 R's card next to the "reduce" line.
- Put jewels from one pile (all of the same color) on your crown.

Are you familiar with the 3 R's?
What are they? Who here recycles at home or at school?

Let's start with reducing.
How can we reduce or use less of in the crown making process?

In green chemistry reducing is the most important R to practice.



17. Discuss one way that you can reuse waste in your crown making process.
18. Write this down on your 3 R's card next to the "reuse" line.
19. Put jewels from one pile (all of the same color) on your crown.



Are there any items that you can reuse at home?
When items are reused they do not go into the waste stream.
What can be reused in the crown making process?

20. Discuss one way that you can recycle waste in your crown making process.
21. Write this down on your 3 R's card next to the "recycle" line.
22. Put the remaining jewels (all of the same color) on your crown.



What are some of the items you can recycle at home or at school?
Recycling is one way to keep our waste down but remember reducing is the most important for E-factor and green chemistry.

23. Discuss how your e-factor has changed with the reduced amount of waste.

How has your E-factor changed with the reduced amount of waste?

What is your new E-factor?
Could you change any of the process steps to reduce waste at the beginning?

Is there a way you can reach the goal of zero in this process?

24. Put the crown on your head and proudly show off your green chemistry crown!

In closing:

Green chemistry provides the tools needed for creating solutions to environmental challenges.

As a green chemist you can be a part of the solution by inventing better technologies for the future. Also remember that you do not need to be a scientist to make a difference in this world. As an informed citizen you have the power to influence change with your decision making, voting power and purchasing choices.

Great Job! Scientists ask questions and seek out answers. Who here asks questions about how products are made or why we have certain problems? Who thought that this was easy? Who had fun doing this? Do you think that science is something that you can do?

Any questions?
Wrapping up is always a good time to talk a little more about why you are in the classroom, what you are studying, researching or pursuing as a career.