

EVIDENCE NOTEBOOK

LESSON 1.2 – CHEMISTRY AND THE ENGINEERING DESIGN PROCESS

KEY WORDS

Key Word	Definition	Example(s)
Engineering design process		
Criteria		
Constraints		
Tradeoff		
System		
Energy		

MAIN CONCEPTS

1. Explain a difference and a similarity between the engineering process and the scientific method.
2. A client wants an engineer to design a bubble bath solution that is purple, makes a certain amount of foam per unit of volume, does not irritate skin, and smells like blueberries. Which of the client's wishes is a constraint?
 - a. purple color
 - b. smells like blueberries
 - c. does not irritate the skin
 - d. makes a certain amount of foam
3. Engineers explore and design solutions to complex real-world problems. Which phrase describes the first step engineers should complete toward finding a solution?
 - a. Define the criteria and constraints.
 - b. Determine environmental impacts.
 - c. Determine groups affected.
 - d. Define the problem.
4. Most plastic used today is produced from nonrenewable fossil fuels and is unable to be broken down naturally by microorganisms. A group of students wants to design a biodegradable plastic made from renewable resources that breaks down more easily and quickly. The students are looking at two possible sources for the primary material for their plastic: algae and cornstarch. Prior to completing a decision matrix, they develop a list of criteria and constraints for each material. Select one material and describe two criteria and at least one constraint for either the algae or cornstarch.

5. A juice company is exploring the use of plastic or glass for its bottle material. The company selects glass because it has a low environmental impact and is more recyclable than plastic. However, glass costs more to manufacture than plastic bottles. Which term is used to describe this decision in the engineering design process?
- Constraint
 - Criterion
 - Disadvantage
 - Tradeoff
6. An automobile engineer decides that increasing the safety of a car by changing the body design outweighs the extra cost that changing the body production process will require. Which word describes this type of decision made during the engineering design process?
- Constraint
 - Criterion
 - System
 - Tradeoff
7. Cotton fabric coated with wax can be used as a wrap for food storage in place of plastic wrap. This product must be a barrier to moisture and be washable and reusable. Engineers want to alter the design to have a better barrier to moisture. Which change could help make the design optimized for this design requirement?
- replace the waxy layer with paper
 - make the waxy layer slightly thicker
 - place the cotton fabric over the waxy layer
 - remove the cotton fabric from under the waxy layer
8. Blood pressure is an indicator of how well the body's circulatory system is working. Patients suffering from high blood pressure are advised to optimize the amount of work and pressure on the heart and circulatory system by improving their diet and increasing activity.

Describe several ways technology could be used to optimize the solution to high blood pressure by improving a patient's activity and diet plan.

9. Burning fossil fuels for energy releases pollutants that affect the air, soil, water, and life on Earth. Why do scientists and engineers try to solve this problem by studying the system as a whole rather than independent parts?
- Some parts cannot be easily studied.
 - The parts of the system are interrelated.
 - Fixing one part fixes the others as well.
 - The inputs and outputs of all parts are the same.
10. When studying climate change, scientists monitor ocean temperatures. For the ocean system, the boundaries are the surface of the ocean and the ocean floor. Which statement describes this system?
- The system is open to both matter and energy.
 - The system is open to either matter or energy.
 - The system is open to energy but not to matter.
 - The system is open to matter but not to energy.
11. Which type of model can be used to run simulations to test the behavior of a complicated system when conditions change?
- Physical
 - Chemical
 - Computer
 - Mathematical
12. Explain the difference between an isolated system and a closed system.
13. Which question could help identify why a designed system failed?
- Was it built within cost constraints?
 - What was the environmental impact?
 - Which safety requirements were not met?
 - How do components of the system interact?
14. A scientist might use a computer simulation to show the three-dimensional shape of a complex molecule. Describe a type of model you could design to accomplish the same goal.

15. Which of the following is not a benefit of multi-scale modeling?
- identifying criteria and constraints
 - understanding systems at different scales
 - developing solutions to a complex problem
 - tracking changes in several variables over time

CHECKPOINTS: Check your understanding

16. Why is it important to identify and rank criteria before designing a solution to an engineering problem?
- to establish a budget for the solution
 - to identify challenges to the solution
 - to avoid pursuing solutions that do not meet key goals or needs
 - to determine the economic impact.
17. Which step would scientists and engineers be least likely to use a model for?
- simulating interactions within or between systems
 - defining and delimiting a problem
 - studying systems at different scales
 - demonstrating the flow of matter or energy through a system
18. An engineer is testing a new recipe for canned vegetable soup. She finds that the squash in the soup gets mushy when the soup is heat-treated to make it safe to eat. She rejects this recipe and tests a new one without squash. What does that indicate about the constraints of the soup design?
- The soup must be safe to eat.
 - The soup must cost less than a certain amount to produce.
 - The soup's texture is not a constraint.
 - The engineer changed her mind about the constraints.
19. *Select (circle) the correct terms to complete the statement about Biosphere 2.*
The Biosphere 2 system was designed to be open | closed to the transfer of matter across its boundaries. The unexpected drop in oxygen in the Biosphere 2 atmosphere resulted from a combination of factors including soil composition and building materials. This indicates that the system boundaries | interactions were not correctly identified.

20. A chemical engineer is developing a manufacturing process for a new kind of fertilizer. Which factor would be unlikely to appear in a diagram of the process?
- amount of reactant input
 - amount of product output
 - boundaries between the system and the environment
 - tradeoffs among different criteria
21. Which statements are true of an open system? *Select all correct answers.*
- Matter enters and leaves the system but energy does not.
 - Both matter and energy leave the system.
 - Energy enters and leaves the system but matter does not.
 - Its boundaries are defined by the person studying the system.
22. You have been hired by a state government to help decide whether to retrofit a coal plant to reduce its emissions or to build a new power plant that does not rely on coal. Place these steps in the order in which you would proceed.
- | | |
|--------|---|
| Step 1 | a. Collect and evaluate data about each model. |
| Step 2 | b. Design models of potential solutions to test whether they meet the criteria and constraints. |
| Step 3 | c. Use the results of testing to choose a solution to use or optimize. |
| Step 4 | d. Identify and define the goals of the project and any limitations such as budget, time, and community concerns. |
23. What are some advantages to modeling a system? What are some limitations?
24. Why is it important to consider potential environmental or social impacts when evaluating possible solutions to a problem? Give an example to support your explanation.

25. How and when does iteration occur in the engineering design process? Why is it such an important aspect of designing solutions? Use an example to explain.

PLASTICS AND POLYMERS VIDEO

Original video: <https://www.youtube.com/watch?v=EoyWY-LIYT8>

Fill in the blank on circle the best choice:

1. Plastics are made from synthetic materials called monomers | polymers which are made up of many monomers | polymers. The process of connecting them together is termed:
_____.
2. The name of the plastic comes from their component monomers | polymers.

High density polyethane (HDPE) vs. Low density polyethane (LDPE):

3. HDPE: Dense, rigid, and strong plastics have polyolefin chains that are straight | branched and packed closely together.
4. LDPE: Lighter, flexible plastics have straight | branched chains and low density.
5. The force of attraction between polymers can be increased by adding _____ linking agents. This will increase the toughness and _____ of the plastic.
6. To make the plastic bend easier (more elastic) _____ are used. They get in between the chains weakening the _____ of _____ between them.

CHALLENGES WITH RECYCLING PLASTICS VIDEO

Original video: https://www.youtube.com/watch?v=N3m_NtQTnfc

Fill in the blank or circle the best choice:

1. The biggest problem with recycling plastics is that there is too much plastic | they are not biodegradable.
2. What are constraints involved with recycling plastic?
 - a. They have to be _____ because not all plastics are recyclable.
 - b. Recycled plastics are often lower quality, this is caused by being _____.
3. How many plastic polymers have been identified worldwide? _____.
4. (True or False) Most plastic recycling centers can handle multiple types of plastics.
5. Other than reducing, recycling, or reusing plastics, what other use could plastic waste serve?
 - a. Your ideas (Video stopped)
 - b. Video's answer
6. What do you think is meant by bioplastics?
 - a. Your ideas (Video stopped)
 - b. Video's answer

7. What is the ethical question that often comes up when considering to make massive amounts of bioplastics?

8. Although some plastics are biodegradable, the conditions for them to breakdown usually require high intensity _____ and commercial composting.

CLARIFICATION TO THE VIDEO

Are Bioplastics Better For The Environment than Conventional Plastics?

The term “bioplastics” is actually used for two separate things: bio-based plastics (plastics made at least partly from biological matter) and biodegradable plastics (plastics that can be completely broken down by microbes in a reasonable timeframe, given specific conditions). Not all bio-based plastics are biodegradable, and not all biodegradable plastics are bio-based. And even biodegradable plastics might not biodegrade in every environment.

“There are a lot of bioplastics or materials that are called bioplastics that are not biodegradable”

Not only that, but none of the standards for plastics labeled as biodegradable or compostable today makes them suitable for disposal in the open environment.

Source

Are bioplastics better for the environment than conventional plastics? (2019). Retrieved from <https://ensia.com/features/bioplastics-bio-based-biodegradable-environment/>