Sustainable chemistry

Green chemistry:

Introduction

Twelve Principle

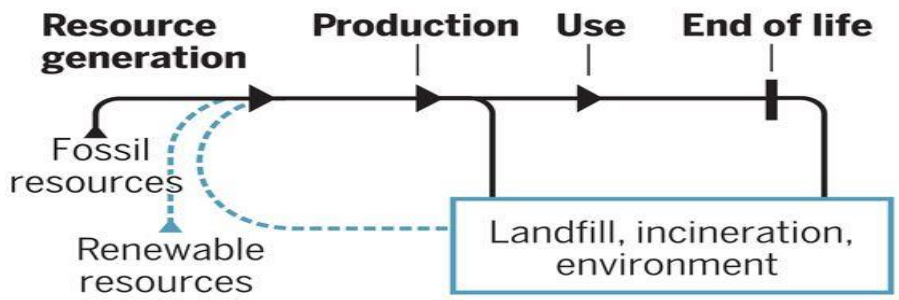
Sustainable Chemistry

- Sustainable chemistry is a modern concept that helps to improve the efficiency with which natural resources are used to meet human needs for chemical products and services.
- Sustainable chemistry is the development and application of chemicals, chemical processes and products that benefit current and future generations without harmful impacts to human or ecosystems.

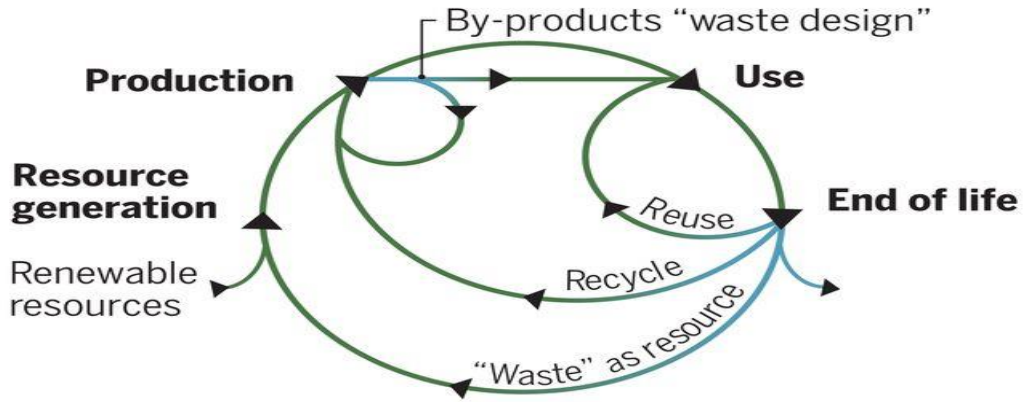
Benefits of sustainable chemistry

- Avoiding the use of persistent, bio accumulative, toxic and other hazardous materials.
- Using renewable resources and decreasing consumption of non-renewable resources.
- Minimizing negative impacts on environmental due to chemical processing and manufacturing.
- Providing technologies that are economically compatible and advantageous to industry.

Today's chemical sector



Tomorrow's chemical sector



Mostly linear processes	Circular processes
Fossil feedstocks	Renewable feedstocks
Reactive, persistent, or toxic chemical reagents and products	Benign chemical reagents and products
Catalysis using rare metals	Catalysis using abundant metals, enzymes, photons, or electrons
Covalent bonds	Weak, noncovalent interactions
Conventional solvents	Low toxicity, recyclable, inert, abundant, easily separable green solvents or solventless
Material- and energy-consuming isolation and purification	Self-separating systems
Large "waste" volume	Atom-, step-, and solvent-economical processes
"Waste" treatment	"Waste" utilization
Design exclusively for use phase with reliance on circumstantial control	Intentional molecule design for full life cycle
Performance = maximize function	Performance = maximize function + minimize hazards
Maximum chemical production for increased profit	Maximum performance with minimal benign material use for increased profit

Green chemistry:-

- Green chemistry is also called sustainable chemistry with developing processes and products to reduce or eliminate hazardous substances.

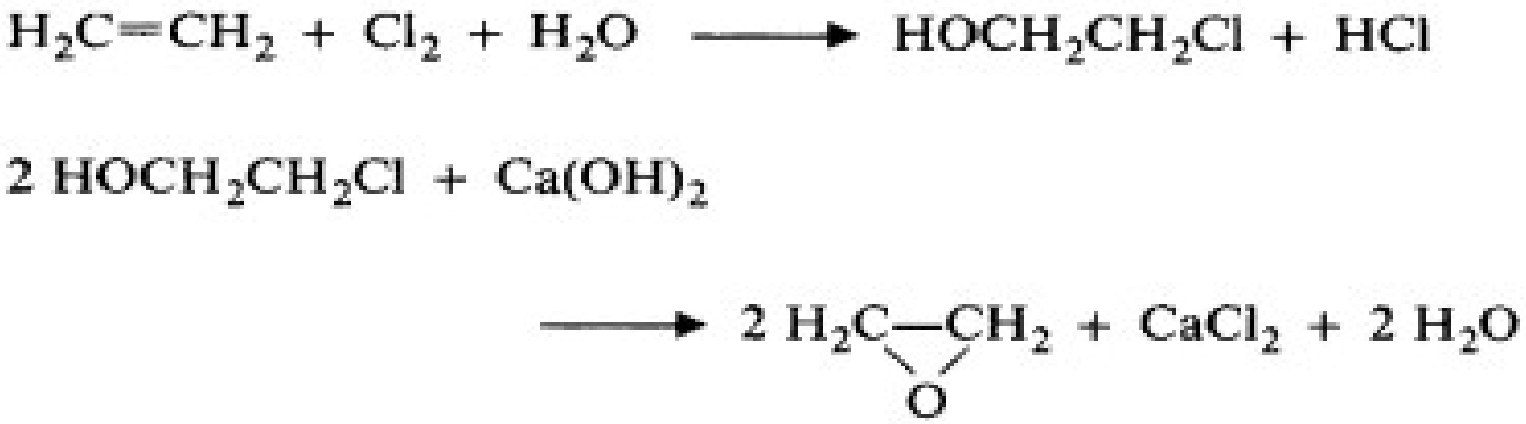
- Green chemistry is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products.
- Green chemistry evolved after 1980's.

Twelve principles of Green Chemistry:-

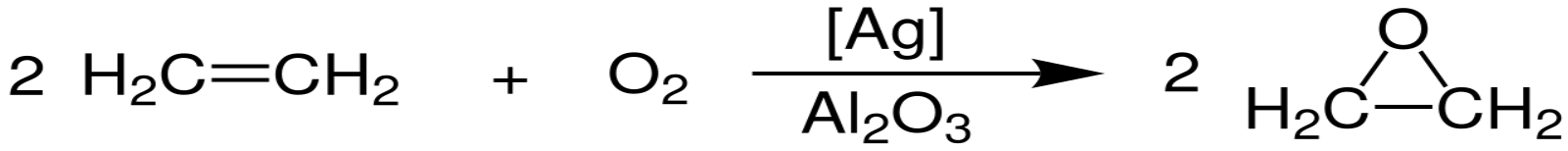
The 12 principles of green chemistry are given below.

1. *Waste prevention:-* prioritize the prevention of waste rather than cleaning or treating waste after it has been created.

Rxn:- Traditional Method of preparation of ethyl oxide(it produces 5kg waste in 1 kg product)



Rxn:- New Method of preparation of ethyl oxide(it produces 0.3kg waste in 1 kg product)



2. Atom Economy:-

Design the reactions so that all atoms present in the reactants are incorporated into the product. It favors addition and rearrangement reaction.

Reactions:-

$NH_3 + HCNO \xrightarrow{\blacktriangle} NH_4CNO$ addition reaction

$NH_4CNO \xrightarrow{\blacktriangle} NH_2CONH_2$ rearrangement reaction

3. Less hazardous chemical synthesis:-

Design and use that synthetic routes which includes less hazardous substances.

4. Designing safer chemicals:-

Predict the toxicity and Environmental impact during synthesis.

5. Use of safer solvents and auxiliaries:-

Instead of Traditional organic solvents(toxic, corrosive ,volatile & inflammable) ,use green solvents(nontoxic, biodegradable like oils, ionic liquids)

6. Design for energy efficiency:-

Design photochemical reaction and avoid the use of non renewable sources(fossils) for synthesize reaction.

7. Use of renewable resources:-

-Use that chemicals which obtain from biomass (renewable sources).

-Biomass → D-Glucose $\xrightarrow{\text{enzymatically}}$ Lactic acid → aliphatic compound

8. Reduce derivatives:-

Avoid derivatives to avoid and minimize reaction steps, resources and wastes.

9. Catalysis:-

Choose catalyzed reaction which helps to increase efficiency, rate of reaction and decrease energy and wastes.

10. Design for degradation:-

Design chemicals that can be degraded easily.

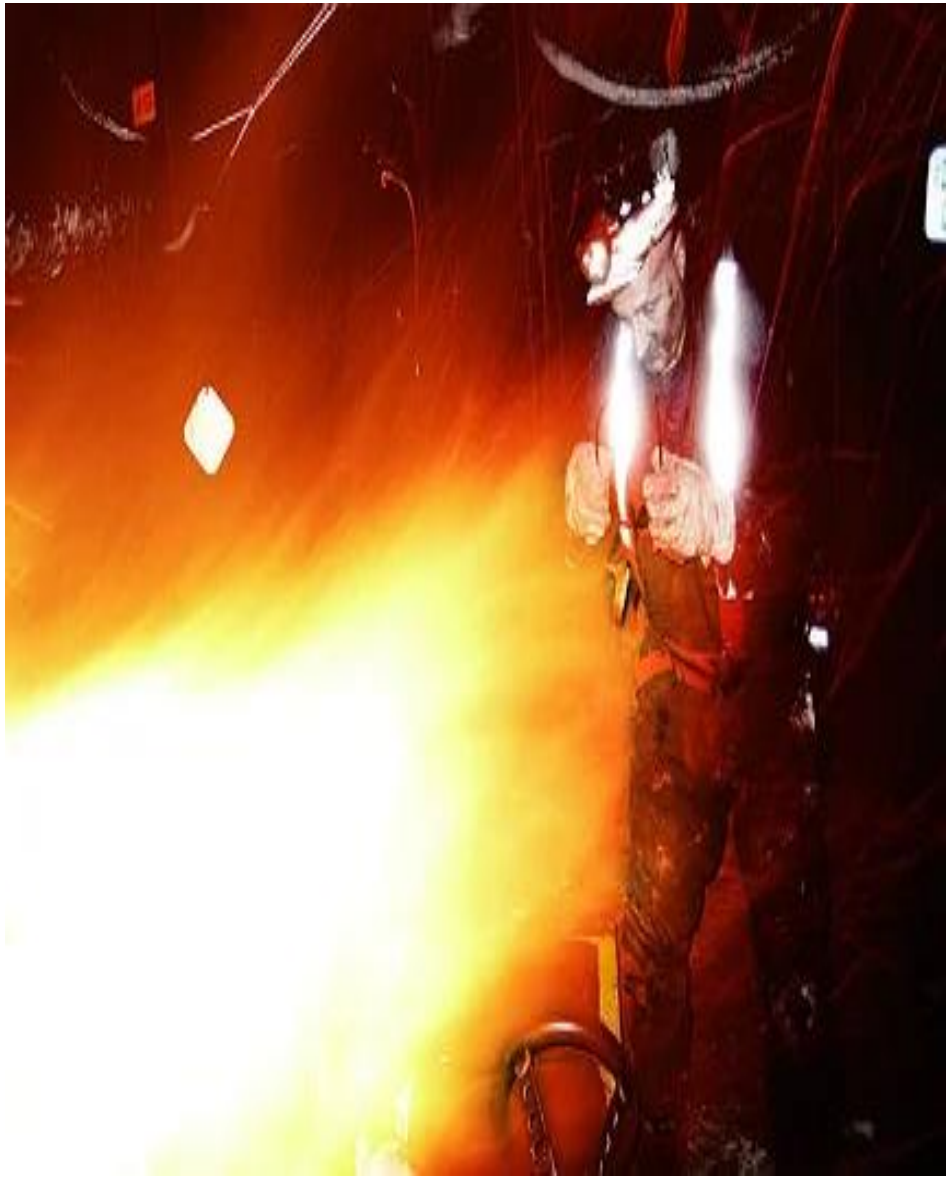
11. Real time analysis for pollution prevention:-

Monitor chemical reaction by Analytical method to predict the formation of hazardous waste.

12. Safer Chemistry for accidental prevention:-

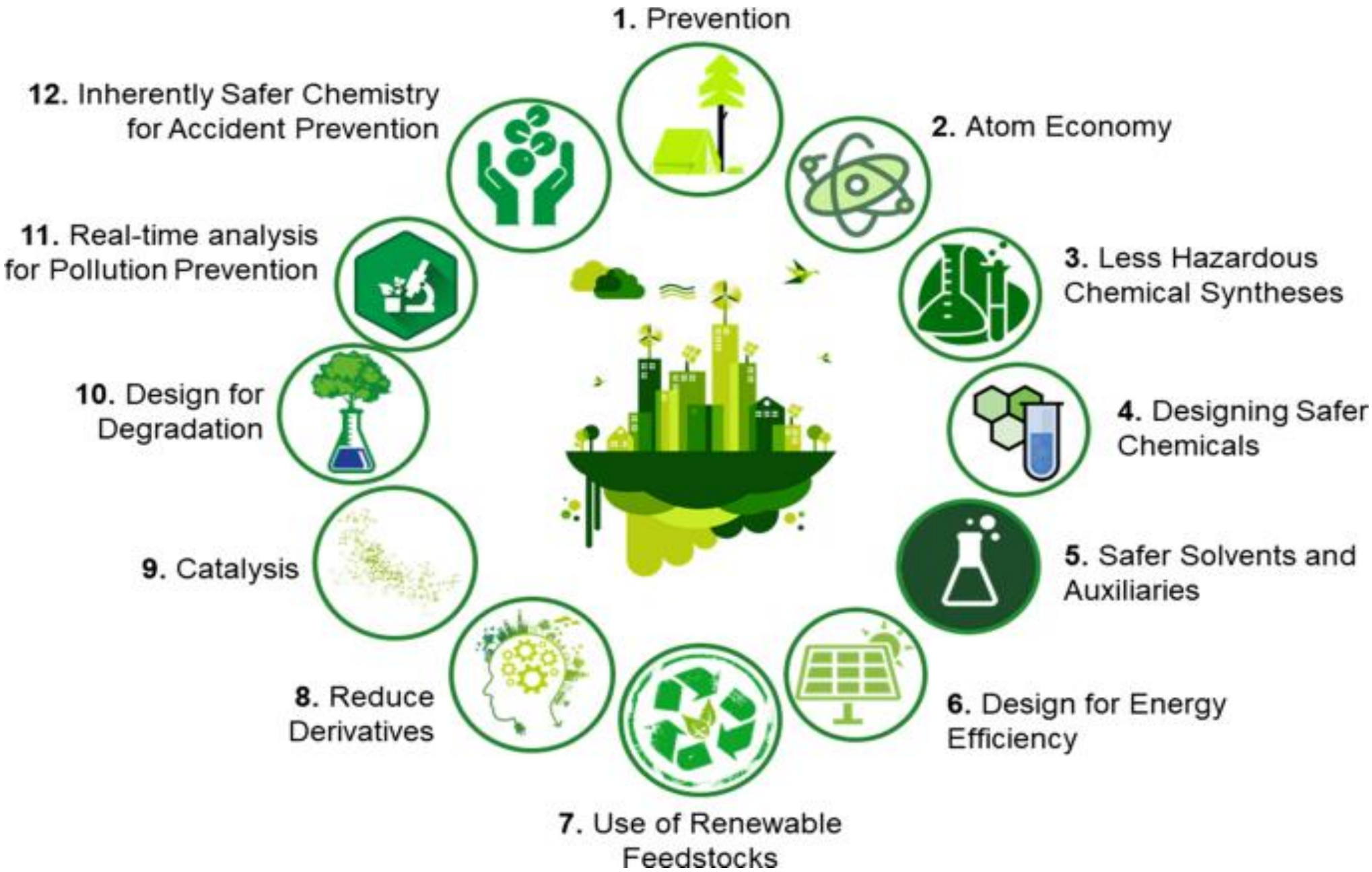
Identify the possible risk before design the manufacturing processes and follow necessary precautions.

Bhopal Gas Tragedy



Application of green chemistry:-

- Economical and Energy efficient
- Lowers cost of production and regulation
- Protects human health and the environment
- Fewer accidents


1. Prevention
2. Atom Economy
3. Less Hazardous Chemical Syntheses
4. Designing Safer Chemicals
5. Safer Solvents and Auxiliaries
6. Design for Energy Efficiency
7. Use of Renewable Feedstocks
8. Reduce Derivatives
9. Catalysis
10. Design for Degradation
11. Real-time analysis for Pollution Prevention
12. Inherently Safer Chemistry for Accident Prevention