

# Green Chemistry

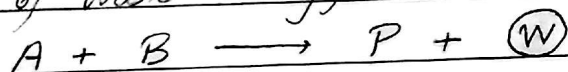
- ① Green Chemistry (Sustainable Chemistry) is a philosophy of chemical research & engineering that encourages the design of products & process that minimise the use & generation of hazardous substances.

\* Green Chemistry reduces

		Hazard	Risk	Cost
	↑	↑	↑	↑
W	H	M	R	E
↓	↓	↓	↓	↓
Waste	Materials	Energy		

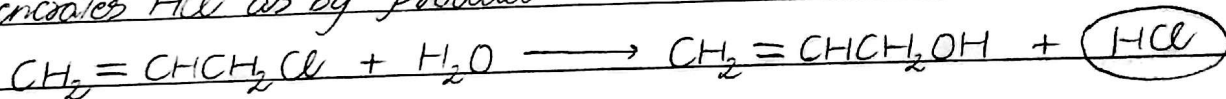
## ② Principles of Green Chemistry -

- ① Prevention of waste (or by products)

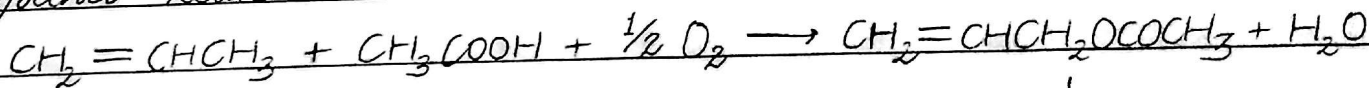


Eg: Synthesis of allyl alcohol -

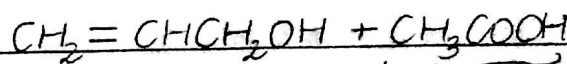
Traditional Route: Alkaline Hydrolysis of allyl chloride which generates HCl as by-product.



Greener Route: To avoid chlorine -



↓



⇒ [No unwanted byproduct]

can be reused for step-1.

(ii) Maximum incorporation of reactants into the final product

$$\% \text{ yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100$$

$$\% \text{ Atom Economy} = \frac{\text{Molecular Weight of final products}}{\text{Molecular Weight of all reactants}} \times 100$$

Note : (a) Addition & Rearrangement Reactions are 100% atom economical.  
(b) Write balanced equation for calculating AE

(iii) Less Hazardous Chemical Synthesis

2 Eg: In the manufacture of polystyrene foam sheet packing material, CFC's which contribute to  $O_3$  depletion, global warming have now been replaced by  $CO_2$  as the blowing agents.

(iv) Design chemical products to preserve efficacy of function while reducing toxicity.

2 Eg: properties of super critical  $CO_2$  makes it possible to be used as a good effective solvent

(v) Use of auxiliary substances (eg: solvents, separation agents, etc) should be made unnecessary wherever possible.

2 Eg: principle applied in development of dry reaction techniques

## (vi) Energy Efficiency

- 2. energy requirements should be small
- 2. For eg: ionic solids work as an excellent solvent under ambient conditions. Such methods can lead to reduction in energy requirements.

## (vii) Use of renewable feedstock

- 2. Eg: biodiesel

## (viii) Derivatization should be minimised

## (ix) Use of catalysts

- 2. enhance the selectivity of a reaction, reduce the temperature of a transformation, reduce reagent-based waste

## (x) Design for degradation

- 2. Design products in such a manner that they degrade automatically within some time.
- Eg: use of DDT as insecticide.

## (xi) Analytical methodologies need to be further developed to allow real time, in-process monitoring & control prior to formation of hazardous substances.

## (ii) Safety Issues

- 2. Substances used in a chemical process should be chosen to minimise potential for chemical accidents, explosions, fires etc

③ Alternative Solvents or green solvents are the one which follow principles of green chemistry. Eg: water & supercritical  $\text{CO}_2$

Eg of non-green solvents: Benzene & tetrachloroethylene

④ Dry media reactions -

- 2. Solid state reaction / Solvent less reaction
- 2. reaction in the absence of a solvent.

⑤ Super critical  $\text{CO}_2$  -

- 2. fluid state of  $\text{CO}_2$ , where it is held at or above its critical temperature & pressure.
- 2. has properties midway b/w a gas & a liquid.