

# 12 Principles of Green Chemistry

1. **Minimize waste.** It is better to prevent waste than to treat or clean up waste after it is formed.
2. **Maximize incorporation.** Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. **Keep it safe.** Wherever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. **Keep it effective.** Chemical products should be designed to preserve efficacy of function while reducing toxicity.
5. **Cut the clutter.** The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.
6. **Mind the energy bill.** Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
7. **Choose renewables.** A raw material of feedstock should be renewable rather than depleting wherever technically and economically practicable.
8. **Use naked chemicals.** Unnecessary derivatization (blocking group, protection/deprotection, temporary modification of physical/chemical processes) should be avoided whenever possible.
9. **Turn up the turnovers.** Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. **Engineer obsolescence.** Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products.
11. **Monitor your progress.** Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. **Check your form.** Substances and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosions, and fires.

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