M.SC Semester III
Core Course XII
Environmental Chemistry

TOPIC:-Unit IV, 12 PRINCIPLES OF GREEN CHEMISTRY

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12 PRINCIPLES OF GREEN CHEMISTRY

1. **Prevention of Waste or by-products**

- It is better to prevent waste than to treat or clean up waste after it is formed

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2. **Atom Economy**

- Atom economy (atom efficiency) describes the conversion efficiency of a chemical process in terms of all atoms involved (desired products produced).

$$Atom\ Economy = \frac{Mol.\ weight\ of\ Desired\ product}{Mol.\ weight\ of\ all\ reactants} \times 100$$

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3. Minimization of hazardous products

- Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to people or the environment.

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4. **Designing Safer Chemicals**

- Chemical products should be designed to effect their desired function while minimising their toxicity.

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5. **Safer Solvents & Auxiliaries**

- “The use of auxiliary substances (e.g. solvents, separation agents, etc.) should be made unnecessary wherever possible, and innocuous when used”

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6. **Design for Energy Efficiency**

- Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized.
- If possible, synthetic methods should be conducted at ambient temperature and pressure.

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6. Design for Energy Efficiency

- Developing the alternatives for energy generation (photovoltaic, hydrogen, fuel cells, bio based fuels, etc.) as well as continue the path toward energy efficiency with catalysis and product design at the forefront.

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7. Use of Renewable Feedstock

- “A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.”

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8. Reduce Derivatives

- Unnecessary derivatization (use of blocking groups, protection/de-protection, and temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

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8. Reduce Derivatives

- More derivatives involve
  - Additional Reagents
  - Generate more waste products
  - More Time
  - Higher Cost of Products
  - Hence, it requires to reduce derivatives.

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9. Catalysis

- Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
- e.g. Toluene can be exclusively converted into p-xylene (avoiding o-xylene & m-xylene) by shape selective zeolite catalyst.

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10. Designing of degradable products

- Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

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11. New Analytical Methods

- “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. Safer Chemicals For Accident Prevention

- “Analytical Substances and the form of a substance used in a chemical process should be chosen to minimise the potential for chemical accidents, including releases, explosions, and fires.”