GREEN CHEMISTRY: PRINCIPLES & CONCEPTS

Definition: Design of chemical products and processes that reduce or eliminate hazardous substances.

1. Prevention – Better to prevent waste than treat it.
2. Atom Economy – Maximize incorporation of all materials.
3. Less Hazardous Chemical Syntheses – Use safer methods.
4. Designing Safer Chemicals – Less toxicity.
5. Safer Solvents & Auxiliaries – Avoid unnecessary use.
6. Energy Efficiency – Run at ambient temperature & pressure.
7. Use of Renewable Feedstocks – Prefer bio-based over fossil.
8. Reduce Derivatives – Avoid unnecessary steps like protection/deprotection.
9. Catalysis – Prefer catalytic reagents over stoichiometric.
10. Design for Degradation – Break down into innocuous products.
11. Real-time analysis – Monitor to prevent pollution.
12. Inherently Safer Chemistry – Minimize accident potential.

Green Solvents

Aim: Reduce environmental and health impact.

- Water – Non-toxic, cheap
- Ethanol – Renewable bio-solvent
- Ionic liquids – Low volatility
- Supercritical CO_2

Supercritical CO_2

State: CO_2 above its critical temperature (31.1°C) and pressure (73 atm).

Properties: Gas-like diffusion, liquid-like solvation.

Uses: Decaffeination of coffee, dry cleaning, polymerization.

Benefits: Non-toxic, recyclable, low environmental impact.

Waste Minimization Techniques

- Source reduction – Redesign processes to generate less waste.
- Recycle/reuse – Reuse solvents, by-products.
- Process optimization – Improve yields, reduce energy.
- Catalysis – Less waste vs. stoichiometric reagents.
- Biodegradable materials – Easier disposal.
- In-process monitoring – Real-time detection of inefficiencies.

Green Catalysis

Goal: Use catalysts to improve efficiency and reduce by-products.

- Biocatalysts – Enzymes (high specificity, mild conditions)
- Heterogeneous catalysts – Easier separation, reusable

- Organocatalysts – Metal-free, less toxic

Advantages: Low energy demand, fewer steps, less waste.

ENVIRONMENTAL CHEMISTRY

Scope: Study of chemical processes in air, water, soil, and living systems.

Importance: Understanding pollution and control, sustainable development, resource conservation, human and ecological health.

Renewable Energy Resources

- Solar Energy – Photovoltaic cells convert sunlight to electricity.
- Wind Energy – Wind turbines harness wind power.
- Hydrothermal – Geothermal energy from Earth's internal heat.
- Tidal Energy – Converts ocean tides into power. Predictable and clean source.

Polymers & Plastics: Environmental Impact

Synthetic Polymers: Non-biodegradable (e.g., polyethylene, PVC)

- Accumulate in landfills
- Microplastic pollution
- Harm marine life and food chains

Solutions: Use of bioplastics, recycling, bans on single-use plastics

Pollution Effects on Human Health

- Air Pollution – Respiratory diseases, asthma, cardiovascular issues
- Water Pollution – Gastrointestinal diseases, heavy metal poisoning
- Soil Pollution – Enters food chain, causes cancer, developmental issues
- Noise Pollution – Hearing loss, stress, sleep disturbances
- Chemical Exposure – Reproductive disorders, neurological problems