

# Green chemistry an introductory text

**Green chemistry an introductory text** is essential for understanding how scientific innovation can lead to more sustainable and environmentally friendly practices in chemical manufacturing and applications. As the world faces increasing environmental challenges, the principles of green chemistry provide a framework for designing processes and products that reduce or eliminate hazardous substances. This article offers an in-depth introduction to green chemistry, exploring its core principles, benefits, and how it is transforming industries around the globe.

## What Is Green Chemistry?

Green chemistry, also known as sustainable chemistry, refers to the design of chemical products and processes that minimize the generation of hazardous substances, reduce energy consumption, and utilize renewable resources. It aims to create more environmentally benign chemicals and processes without compromising efficiency or economic viability.

## Definition and Scope

Green chemistry is a proactive approach to chemical manufacturing that emphasizes:

1. Reducing waste and byproducts
2. Choosing safer chemical ingredients
3. Designing energy-efficient processes
4. Utilizing renewable raw materials
5. Preventing pollution at the source

This approach contrasts with traditional chemistry, which often relies on hazardous reagents, produces toxic waste, and consumes significant energy.

## The Importance of Green Chemistry

As industries worldwide seek sustainable solutions, green chemistry offers multiple benefits:

1. Environmental protection
2. Cost savings through waste reduction
3. Worker safety improvements
4. Regulatory compliance and risk management
5. Innovation in product development

By adopting green chemistry principles, companies can not only improve their environmental footprint but also enhance their competitiveness in a market increasingly driven by sustainability.

## Core Principles of Green Chemistry

The foundation of green chemistry is built on 12 fundamental principles, first articulated by Paul Anastas and John Warner in 1998. These principles guide chemists in designing safer, more sustainable chemical processes.

## **1. Prevention**

It is better to prevent waste than to treat or clean up waste after it has been created. Designing processes that avoid waste formation is the cornerstone of green chemistry.

## **2. Atom Economy**

Maximize the incorporation of all materials used in the process into the final product, reducing waste and improving efficiency.

## **3. Less Hazardous Chemical Syntheses**

Design synthetic methods that are safer for human health and the environment, avoiding the use of toxic reagents and intermediates.

## **4. Designing Safer Chemicals**

Chemicals should be designed to accomplish their desired function while minimizing toxicity and environmental impact.

## **5. Safer Solvents and Auxiliaries**

Use safer solvents, or eliminate the need for solvents altogether, to reduce environmental and health hazards.

## **6. Design for Energy Efficiency**

Conduct chemical reactions at ambient temperature and pressure whenever possible, minimizing energy consumption.

## **7. Use of Renewable Feedstocks**

Prefer renewable raw materials over finite resources to promote sustainability.

## **8. Reduce Derivatives**

Minimize the use of unnecessary derivatization steps, which often generate waste.

## **9. Catalysis**

Use catalytic rather than stoichiometric reagents to increase efficiency and reduce waste.

## **10. Design for Degradation**

Design chemicals so they break down into innocuous substances after use, minimizing environmental persistence.

## **11. Real-time Analysis for Pollution Prevention**

Implement analytical techniques during manufacturing to monitor and control processes, preventing pollution.

## 12. Inherently Safer Chemistry for Accident Prevention

Choose substances and processes that reduce the risk of accidents, such as explosions or releases.

## Applications of Green Chemistry

Green chemistry principles are applied across various industries, transforming traditional practices into more sustainable alternatives.

### Pharmaceutical Industry

- Designing synthetic routes that minimize hazardous reagents and waste - Using greener solvents and catalysts - Developing safer drug delivery systems

### Agrochemical Industry

- Creating pesticides and fertilizers with reduced toxicity - Utilizing biodegradable formulations - Employing renewable raw materials

### Manufacturing and Materials

- Producing polymers and plastics with non-toxic, renewable feedstocks - Developing sustainable dyes and pigments - Innovating with biodegradable packaging materials

### Energy Sector

- Designing energy-efficient manufacturing processes - Developing renewable energy technologies - Creating catalysts for cleaner fuel production

## Benefits and Challenges of Green Chemistry

Implementing green chemistry offers numerous advantages but also presents certain challenges that must be addressed.

### Benefits

1. Environmental Sustainability: Reduces pollution and conserves resources
2. Economic Efficiency: Lowers costs associated with waste treatment and disposal
3. Regulatory Compliance: Meets increasingly strict environmental laws
4. Market Advantage: Meets consumer demand for eco-friendly products
5. Innovation: Drives the development of new, sustainable products and processes

### Challenges

1. Initial Investment: Higher upfront costs for research and development
2. Technical Limitations: Difficulty in replacing traditional reagents or processes
3. Knowledge Gap: Need for education and training in green chemistry principles
4. Scale-Up Issues: Challenges in translating laboratory successes to industrial scales

# Future of Green Chemistry

The future of green chemistry is promising, driven by technological advances, policy support, and a global shift towards sustainability. Emerging trends include:

1. Integration of green chemistry with circular economy models
2. Development of biodegradable and recyclable materials
3. Advancement in catalysis and process intensification
4. Use of computational tools and artificial intelligence for designing greener processes
5. Increased collaboration between academia, industry, and government

As research progresses, green chemistry will continue to play a pivotal role in creating a sustainable future, reducing environmental impact, and fostering innovation across industries.

## Conclusion

**Green chemistry an introductory text** offers a glimpse into a transformative approach to chemical science—one that prioritizes sustainability, safety, and efficiency. By adhering to its core principles, industries can develop products and processes that are not only environmentally friendly but also economically advantageous. As the world increasingly recognizes the importance of sustainable development, green chemistry stands at the forefront, guiding us toward a cleaner, healthier planet for future generations. Whether you are a student, scientist, or industry professional, understanding the fundamentals of green chemistry is essential for contributing to this vital movement.

**Green Chemistry: An Introductory Overview** In an era marked by escalating environmental challenges and a pressing need for sustainable development, the field of green chemistry emerges as a beacon of innovative scientific progress. As a transformative approach to chemical research and manufacturing, green chemistry aims to design products and processes that minimize or eliminate the use of hazardous substances, reduce waste, and conserve energy. This comprehensive overview provides an in-depth look into the core principles, significance, applications, and future prospects of green chemistry, serving as an essential primer for scientists, industry professionals, policymakers, and environmentally conscious consumers alike.

## Understanding Green Chemistry: Definition and Core Principles

What is Green Chemistry? Green chemistry, also known as sustainable chemistry, is a branch of chemical sciences that emphasizes the development of products and processes that are environmentally benign. Unlike traditional chemistry, which often focuses solely on efficiency, yield, and cost-effectiveness, green chemistry integrates environmental and health considerations into every stage of chemical design and application. The concept was formally articulated in 1998 by Paul Anastas and John Warner through the 12 Principles of Green Chemistry, which serve as guiding pillars for sustainable chemical innovation. These principles foster the creation of safer, cleaner, and more efficient chemical processes that align with ecological and human health goals. The 12 Principles of Green Chemistry

1. Prevention: It is better to prevent waste than to treat or clean up waste after it has been created.
2. Atom Economy: Synthetic methods should maximize the incorporation of all materials used into the final product.
3. Less Hazardous Chemical Syntheses: Synthetic methods should use and generate substances with minimal toxicity.
4. Designing Safer Chemicals: Chemical products should be designed to be effective yet safe for human health and the environment.
5. Safer Solvents and Auxiliaries: Use of safer solvents and auxiliary substances to minimize environmental impact.
6. Design for Energy Efficiency: Chemical processes should be

conducted at ambient temperature and pressure whenever possible. 7. Use of Renewable Feedstocks: Preference should be given to renewable raw materials over finite resources. 8. Reduce Derivatives: Minimize unnecessary derivatization to reduce waste. 9. Catalysis: Employ catalytic processes to increase efficiency and selectivity. 10. Design for Degradation: Chemical products should break down into innocuous substances after use. 11. Real-time Analysis for Pollution Prevention: Incorporate analytical techniques to monitor processes and prevent pollution. 12. Inherently Safer Chemistry for Accident Prevention: Use substances and processes that minimize the risk of accidents. These principles serve as an ethical and scientific framework for rethinking traditional chemical practices, encouraging innovation that aligns with environmental stewardship.

## The Significance of Green Chemistry

**Environmental Benefits** Green chemistry directly addresses the adverse effects of conventional chemical manufacturing, such as toxic waste, greenhouse gas emissions, and resource depletion. By designing processes that reduce or eliminate hazardous substances, green chemistry helps:

- Minimize toxic effluents and emissions.
- Reduce greenhouse gases contributing to climate change.
- Conserve finite resources through renewable feedstocks.
- Promote biodegradability and safe disposal of chemical products.

**Economic and Industrial Advantages** Adopting green chemistry principles can lead to substantial economic benefits for industries, including:

- Cost savings through reduced raw material usage and waste management.
- Increased process efficiency and yield.
- Enhanced corporate reputation and market competitiveness.
- Compliance with stricter environmental regulations, avoiding penalties.

**Human Health and Safety** Green chemistry prioritizes the development of safer chemicals and processes, significantly reducing occupational hazards and environmental exposure risks. This focus results in:

- Safer workplaces.
- Reduced health risks for consumers.
- Safer products for everyday use.

**Innovation and Competitive Edge** Green chemistry fuels innovation by encouraging the development of new materials and technologies. For example, bio-based plastics, non-toxic dyes, and biodegradable surfactants are products rooted in green chemistry principles. Companies investing in green chemistry often gain a competitive edge by aligning with consumer demand for sustainable products.

## Core Areas and Applications of Green Chemistry

1. **Green Solvents and Auxiliaries** Traditional solvents like benzene, toluene, and chlorinated hydrocarbons are often toxic and environmentally persistent. Green chemistry promotes the use of:

- **Water:** The most abundant, non-toxic solvent.
- **Supercritical CO<sub>2</sub>:** Used in extraction and cleaning processes.
- **Ionic liquids:** Salts that are liquid at room temperature and have low vapor pressure.
- **Bio-based solvents:** Derived from renewable resources, such as ethanol and glycerol.

2. **Catalysis** Catalysts improve reaction efficiency and selectivity, reducing waste and energy consumption. Examples include:

- **Enzymes** in biocatalysis.
- **Heterogeneous catalysts** in industrial processes.
- **Metal complexes** that facilitate specific transformations.

3. **Renewable Feedstocks** Replacing finite resources like petroleum with renewable alternatives such as:

- **Plant oils and sugars.**
- **Agricultural waste.**
- **Algae-derived materials.**

4. **Designing Safer Chemicals** Creating products that perform their intended function without harming humans or ecosystems. For example:

- **Non-toxic dyes and pigments.**
- **Biodegradable detergents.**
- **Safer pesticides and herbicides.**

5. **Energy Efficiency** Processes designed to operate at ambient conditions reduce energy consumption. Techniques include:

- **Microwave-assisted synthesis.**
- **Flow chemistry** enabling continuous processing.
- **Photocatalysis** driven by sunlight.

6. **Waste Prevention and Management** Implementing strategies like process intensification and recycling to minimize waste generation.

## Green Chemistry in Action: Practical Examples

1. **Biodegradable Plastics** Materials like polylactic acid (PLA) are produced from renewable plant starches and

degrade naturally, reducing plastic pollution. 2. Solar-Driven Synthesis Using sunlight as an energy source in chemical reactions decreases reliance on fossil fuels and reduces carbon footprint. 3. Catalytic Conversion of Biomass Transforming agricultural waste into biofuels or chemicals through catalytic processes exemplifies sustainable resource utilization. 4. Green Detergents Replacing phosphates and phosphonates with biodegradable surfactants improves wastewater quality and aquatic life safety. 5. Green Extraction Techniques Supercritical CO<sub>2</sub> extraction is employed in coffee decaffeination and essential oil purification, avoiding toxic solvents.

## The Challenges and Future Directions of Green Chemistry

**Current Challenges** While green chemistry offers numerous benefits, several hurdles remain: - **Cost and Scalability:** Some green processes are initially more expensive or challenging to scale up. - **Limited Awareness and Education:** Widespread adoption requires training and cultural shifts within industries. - **Material Limitations:** Not all traditional chemicals have green alternatives yet. - **Regulatory Frameworks:** Need for policies that incentivize green chemistry innovations. **Future Prospects** The future of green chemistry is promising, driven by technological advancements and societal demand for sustainability. Key areas of development include: - **Advanced Catalysts:** Designing more efficient and selective catalysts, including nanocatalysts. - **Synthetic Biology:** Engineering microorganisms to produce chemicals and materials sustainably. - **Circular Economy Integration:** Designing chemicals and processes that fit within closed-loop systems. - **Policy and Education:** Strengthening regulations and spreading awareness to accelerate adoption. **Emerging Trends** - Adoption of digital tools such as computer-aided molecular design. - Integration of life cycle assessment (LCA) in process development. - Expansion of green metrics to evaluate environmental impact rigorously.

## Conclusion: Embracing Green Chemistry for a Sustainable Future

Green chemistry represents a paradigm shift in how we conceive, design, and implement chemical processes and products. Its principles foster innovation that aligns with environmental integrity, human health, and economic viability. From developing biodegradable plastics to pioneering energy-efficient syntheses, green chemistry's scope is vast and impactful. As industries and societies confront the realities of climate change, resource scarcity, and pollution, embracing green chemistry is no longer optional—it is essential. Through continued research, education, and policy support, green chemistry can catalyze a transition toward a more sustainable, resilient, and healthier planet. Whether you are a scientist, business leader, or consumer, understanding and supporting green chemistry initiatives can contribute to a cleaner, safer future for all.

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Students also experience clear benefits. Academic success often depends on access to reliable study materials. Digital PDFs support offline learning, repeated review, and efficient note-taking. The ability to organize files digitally reduces stress and improves focus, allowing students to manage multiple subjects more effectively.

Digital access supports diverse learning styles. Some readers prefer structured, linear reading, while others focus on specific sections or revisit content selectively. Digital formats accommodate both approaches. Readers can

skim, search, annotate, or study deeply depending on their goals and preferences.

Accessibility features further expand the reach of digital books. Adjustable font sizes, screen reader compatibility, night modes, and text-to-speech functions help ensure that **Green Chemistry An Introductory Text** remains usable for readers with different needs. Inclusive design makes knowledge more equitable and widely available.

Environmental considerations add another perspective. Producing and transporting printed books requires significant resources. While digital technology has its own environmental footprint, distributing books electronically often reduces paper usage and physical transportation. Downloading **Green Chemistry An Introductory Text** contributes to a more efficient and sustainable model of information sharing.

Organization is another understated advantage of digital libraries. Files can be categorized, labeled, backed up, and retrieved instantly. Readers can build long-term collections without physical clutter. When information is organized effectively, it becomes easier to revisit ideas and build upon previous learning.

Global accessibility is one of the most powerful aspects of digital books. Readers from different countries and backgrounds can access the same material without delay. This shared access fosters dialogue, collaboration, and cultural exchange. Downloading **Green Chemistry An Introductory Text** connects individuals to a broader global learning community.

Digital literacy naturally develops through regular interaction with digital resources. Learning how to evaluate sources, manage information, and use reading tools responsibly is now a vital skill. Engaging with **Green Chemistry An Introductory Text** in digital form helps users build these competencies through practical experience.

Perhaps the most meaningful change lies in how digital access influences attitudes toward learning. When information is easy to obtain, curiosity feels encouraged rather than inconvenient. Readers are more willing to explore new topics, revisit familiar ideas, and continue learning over time.

This mindset supports lifelong learning. Education becomes an ongoing process shaped by evolving interests and challenges. Having **Green Chemistry An Introductory Text** available digitally ensures that learning remains flexible and adaptable throughout different stages of life.

In conclusion, the ability to download **Green Chemistry An Introductory Text** reflects a broader transformation in how knowledge is shared and experienced. Digital access offers convenience, affordability, functionality, and ethical distribution, making learning more inclusive and practical. When used responsibly, **Green Chemistry An Introductory Text** becomes more than a digital book—it becomes a trusted resource for reflection, growth, and continuous intellectual development in an ever-changing world.

## Questions & Answers About green chemistry an introductory text

| No | Question | Answer |
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|---|----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | What is green chemistry and why is it important?                     | Green chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances. It is important because it promotes sustainability, reduces environmental impact, and enhances safety in chemical industries.                                                                     |
| 2 | What are the 12 principles of green chemistry?                       | The 12 principles include waste prevention, atom economy, less hazardous chemical syntheses, designing safer chemicals, safer solvents and auxiliaries, energy efficiency, use of renewable feedstocks, reduce derivatives, catalysis, design for degradation, real-time analysis for pollution prevention, and inherently safer chemistry. |
| 3 | How does green chemistry contribute to sustainability?               | Green chemistry contributes to sustainability by minimizing resource consumption, reducing waste and pollutants, and developing safer chemicals and processes that support environmental health and economic viability.                                                                                                                     |
| 4 | Can you give an example of a green chemistry application?            | One example is the use of bio-based solvents like ethanol or supercritical CO <sub>2</sub> instead of traditional toxic solvents in manufacturing, which reduces hazardous waste and environmental impact.                                                                                                                                  |
| 5 | What are the challenges faced in adopting green chemistry practices? | Challenges include high initial costs, lack of awareness or expertise, existing regulatory hurdles, and the need for research and development of sustainable alternatives.                                                                                                                                                                  |
| 6 | How does green chemistry influence product design?                   | Green chemistry encourages designing products that are safer for consumers and the environment, easier to recycle or biodegrade, and produced with minimal hazardous substances.                                                                                                                                                            |
| 7 | What role do education and policy play in promoting green chemistry? | Education raises awareness and equips future chemists with green principles, while policies and regulations can incentivize sustainable practices and the adoption of green chemistry technologies.                                                                                                                                         |
| 8 | Where can I find an introductory text on green chemistry?            | An excellent starting point is 'Green Chemistry: An Introductory Text' by Mike Rowe and Paul T. Anastas, which provides foundational concepts and principles for beginners.                                                                                                                                                                 |

green chemistry, sustainable chemistry, environmental chemistry, eco-friendly practices, chemical innovation, green synthesis, pollution prevention, sustainable materials, environmentally benign reactions, green technologies

# Green Chemistry An Introductory Text

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Readers can incorporate Green Chemistry An Introductory Text eBooks into daily routines without significant time or space requirements.

## **Sharing Green Chemistry An Introductory Text**

Sharing Green Chemistry An Introductory Text with others can be a positive way to spread knowledge, encourage learning, and build communities around shared interests. However, responsible and legal sharing is essential to respect copyright laws and support the authors and publishers who create valuable content. Understanding what can and cannot be shared helps prevent legal issues and ensures ethical use of digital materials.

In general, only free, open-access, or public domain versions of Green Chemistry An Introductory Text may be shared freely. Public domain works are no longer protected by copyright and can be distributed without restrictions. Many classic texts, government publications, and educational resources fall into this category. Trusted platforms such as public libraries and reputable digital archives clearly label content that is legally shareable.

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### **Ethical considerations when sharing**

Beyond legal requirements, ethical considerations play an important role. Sharing unauthorized copies can harm authors and publishers by reducing potential income and discouraging future content creation. Supporting legal distribution ensures that high-quality Green Chemistry An Introductory Text materials continue to be produced and updated. Ethical sharing builds trust and sustainability within reading and learning communities.

### **Finding Reviews**

Reading reviews is one of the most effective ways to choose the best edition of Green Chemistry An Introductory Text. With many versions, formats, and publishers available, reviews help readers avoid low-quality or poorly formatted editions and focus on content that meets their expectations.

Online bookstores often feature customer reviews and ratings that provide insights into readability, formatting quality, and overall satisfaction. Paying attention to detailed reviews can reveal common issues such as missing pages, poor editing, or compatibility problems with certain devices. Reviews that mention specific strengths or weaknesses are especially useful when selecting a digital version of Green Chemistry An Introductory Text.

Community-driven platforms such as Goodreads, Reddit, and specialized forums offer additional perspectives. These communities allow readers to discuss content in depth, compare editions, and share personal experiences. Recommendations from experienced readers or subject-matter enthusiasts can be particularly valuable when choosing educational or technical Green Chemistry An Introductory Text materials.

Professional reviews from blogs, academic journals, or reputable websites can also provide objective evaluations. These reviews often focus on content accuracy, relevance, and usefulness, making them helpful for students and professionals who rely on reliable information.

### **Evaluating review credibility**

Not all reviews carry the same level of reliability. When reading reviews, consider the reviewer's background, level of detail, and consistency with other feedback. Multiple reviews highlighting similar strengths or weaknesses



usually indicate a genuine pattern. Avoid relying solely on extreme opinions and instead look for balanced assessments that discuss both pros and cons of the Green Chemistry An Introductory Text edition.

### **Using Audiobooks**

Audiobooks offer an alternative way to experience Green Chemistry An Introductory Text content and are increasingly popular among modern readers. Instead of reading text, users listen to narrated versions, allowing them to engage with content while performing other tasks. Audiobooks are especially useful during commuting, exercising, or completing routine activities.

Platforms such as Audible, Google Audiobooks, Apple Books, and Scribd offer professionally narrated audiobooks of many Green Chemistry An Introductory Text titles. These versions often feature high-quality narration, clear pronunciation, and structured pacing that enhances understanding. Some audiobooks also include chapter navigation, bookmarks, and playback speed controls for added convenience.

For public domain works, platforms like LibriVox provide free audiobooks narrated by volunteers. While narration quality may vary, LibriVox remains a valuable resource for accessing classic or open-access versions of Green Chemistry An Introductory Text without cost. Listening to samples before committing to a full audiobook can help ensure a comfortable listening experience.

Audiobooks are particularly beneficial for auditory learners or individuals with visual impairments. They also help reduce screen time, making them a healthy alternative for extended content consumption. However, audiobooks may not be ideal for detailed study that requires frequent referencing, highlighting, or visual analysis.

### **Combining audiobooks with text**

Many readers find value in combining audiobooks with digital or printed text. Listening while following along in the text can improve comprehension and retention. Others use audiobooks for initial exposure and then refer to the text version of Green Chemistry An Introductory Text for deeper study. This multi-format approach maximizes flexibility and learning efficiency.

### **Tracking Progress**

Tracking reading progress is a powerful way to stay motivated and organized when engaging with Green Chemistry An Introductory Text. Monitoring progress helps readers set goals, manage time effectively, and reflect on what they have learned. Whether reading for leisure, study, or professional development, tracking tools enhance accountability and consistency.

Apps such as Goodreads, StoryGraph, and LibraryThing allow users to log books, track reading status, write reviews, and set annual or monthly reading goals. These platforms also offer personalized recommendations based on reading history, making it easier to discover related Green Chemistry An Introductory Text materials.

For readers who prefer a more customized approach, spreadsheets or note-taking apps can serve as effective tracking tools. Creating a simple reading log that includes dates, chapters completed, key notes, and personal reflections helps organize learning and maintain focus. Digital notes can be linked directly to highlighted sections within Green Chemistry An Introductory Text for easy reference.

### **Using tracking for study and research**

For academic or professional purposes, tracking progress goes beyond simple completion. Recording insights, questions, and references while reading Green Chemistry An Introductory Text creates a structured knowledge base that can be revisited later. This approach supports deeper understanding and improves long-term retention of

information.

Tracking tools also help identify patterns in reading habits, such as preferred formats or optimal reading times. Understanding these patterns allows readers to adjust their routines for better productivity and enjoyment.

### **Community engagement and motivation**

Sharing progress within reading communities can increase motivation and accountability. Many platforms allow users to join reading challenges, discussion groups, or book clubs centered around specific topics or genres. Engaging with others who are also reading *Green Chemistry An Introductory Text* fosters discussion, insight exchange, and a sense of shared purpose.

However, sharing progress should always respect privacy preferences. Users can choose what information to make public and what to keep personal. Balanced participation ensures that tracking remains a supportive tool rather than a source of pressure.

### **Final thoughts on sharing and managing *Green Chemistry An Introductory Text***

Responsible sharing, informed selection, and effective tracking are key aspects of enjoying *Green Chemistry An Introductory Text* in the digital age. By respecting copyright, relying on trusted reviews, exploring audiobooks, and monitoring reading progress, readers can create a well-rounded and ethical reading experience. These practices not only enhance personal understanding but also contribute to a sustainable and supportive reading ecosystem built around high-quality *Green Chemistry An Introductory Text* content.