



# ENVIRONMENTAL CHEMISTRY



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## MAJOR THEMES

### Atmosphere, Hydrosphere & Geosphere Overlap

- **Atmosphere:** the 10,000-km layer of gas enveloping Earth
  - Regulates climate, protects life from solar radiation
- **Hydrosphere:** all of Earth's water
  - Vital for chemical cycling and supporting life; impacts climate patterns
- **Geosphere:** Earth's solid layer, including rocks and soil

### Biogeochemical cycling

- Movement and transformation of elements and compounds between living organisms and the atmosphere, hydrosphere, and geosphere
- Natural processes, such as precipitation and erosion, drive this phenomenon
- Anthropogenic processes, such as fossil fuel combustion, also contribute
- Conservation of mass: mass is neither created nor destroyed in an isolated system
  - Underpins biogeochemical cycles and the flow of pollutants

- Most molecules and minerals can exist in air, water, or soil
  - Their natural biogeochemical cycles reflect such transformations

- Flow between environments has important consequences
  - Generally impossible to fully prevent industrial byproducts, emissions, and pollutants from affecting the surrounding environment

- **Thermodynamics** assess direction and extent of chemical processes
  - $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

- **Kinetics** assess their speed

- Changes in temperature and pressure alter the energy and solubility of substances, thereby altering reaction of both direction and speed

### Abiotic & Biotic Overlap

- **Abiotic components:** nonliving elements, such as minerals, water, and air, which affect ecosystems
- **Biotic components:** living and once-living elements, such as soil microbes, plankton, and animal decay
- Underlying principle of biogeochemistry—elements cycle freely between living organisms and the “nonliving” environment
- Components of one organism's DNA can transform over time into carbon dioxide for plants, gaseous  $N_2$  for nitrogen-fixing microbes, sugar in a banana, phosphorus in a mineral deposit, benzene in crude oil, or smog in the atmosphere
- Reverse is also true—mercury in crude oil can accumulate in fish; volcanic sulfur can wind up in eggs

### Anthropogenic Effects

- Originate from human activity (e.g., industrial pollution, urban runoff)
- See *Pollution*, p. 4 and *Anthropogenic Effects*, p. 6, for further discussion

### Industrial compounds & processes

- Can impact:
  - Surrounding ecosystems (e.g., car emissions create smog in a city)
  - Distant ecosystems (e.g., microplastic pollution in the deepest parts of the ocean)
  - Future ecosystems (e.g., climate change and climate feedback)

### Extractive processes

- The power of anthropogenic effects often arises from extractive processes (e.g., mining, deforestation, and production of fossil fuels)
- This accentuates individual facets of a biogeochemical cycle
  - EX: Burning fossil fuels transfers nearly 40 billion tons of  $CO_2$  from Earth into the atmosphere. This unnatural shift disrupts the carbon cycle and Earth's other abiotic, biotic, atmospheric, aquatic, and soil systems.

### Climate feedback

- Self-reinforcing processes
- Change in one facet of global climate triggers additional changes
  - Amplifies or dampens the initial change
- EX: As rising global temperatures melt polar ice caps, Earth's reflectivity (albedo) decreases, leading to more absorption of solar radiation and more warming.



For other chemical cycles, see p. 6

## ATMOSPHERIC CHEMISTRY

### Key Definitions & Concepts

- **Aerosols:** influence climate by scattering and absorbing solar radiation and serving as cloud condensation nuclei
  - Can also have adverse health effects when inhaled, leading to respiratory issues
- **Carbon dioxide:** primarily from burning fossil fuels and deforestation
  - Natural sinks, such as oceans, marine photosynthesizers, and forests, absorb and sequester carbon
  - Help regulate atmospheric  $CO_2$  levels
  - Sometimes lead to other problems, such as ocean acidification
- **Free radicals**
  - Hydroxyl radicals ( $HO^\bullet$ ): drive atmospheric reactions that lead to smog
  - Nitric oxide ( $NO$ ): a GHG pollutant; precursor to nitrogen oxides ( $NO_x$ )
  - Chlorine ( $Cl$ ): depletes ozone ( $O_3$ ) in the stratosphere
- **Greenhouse gases (GHG):** trap heat by absorbing incoming sunlight and dissipating that heat across the atmosphere
  - EX: carbon dioxide, methane, nitrous oxide ( $N_2O$ )
- **Methane:** more potent, less abundant GHG than  $CO_2$ 
  - Sources include livestock, clothes manufacturing, natural gas production, and wetland microbes
- **Nitrous oxide**
  - Soil and oceans form natural sinks
  - Sources include agricultural activities and combustion
- **Radioactive decay:** spontaneous process where unstable atomic nuclei (e.g., alpha particles, beta particles, or gamma rays) emit radiation
- **Radon:** radioactive gas released from decay of uranium in soil and rocks
  - Known carcinogen
- **Stratospheric ozone:** absorbs UVB radiation, reducing radiation that reaches Earth's surface
- **Tropospheric ozone (ground-level ozone):** forms from light-accelerated reactions of oxides and VOCs
  - Harmful to health and the ecosystem
- **Volatile organic compounds (VOCs):** small, airborne molecules at room temperature
  - Impact human health and contribute to ozone and particulate formation (e.g., benzene, toluene, acetone, formaldehyde)
- **Water droplets** can act as PM in the atmosphere
  - Trigger cloud formation and precipitation, reduce visibility
  - Humid air traps pollutants near the ground, worsening smog
- **Water vapor:** more abundant GHG than  $CO_2$ 
  - Shorter lifetime in the atmosphere makes it less problematic

### Photosynthesis

- **Origins:** 3+ billion years ago, cyanobacteria evolved the ability to split water molecules and produce oxygen as a byproduct
- This early photosynthesis led to the **Great Oxidation Event**
  - Increased Earth's atmospheric oxygen levels
  - Allowed for the evolution of all aerobic life forms

### Radiative forcing

- **Disrupted balance** of incoming solar radiation versus outgoing infrared radiation
  - Due to atmospheric composition
- **Positive forcing:** traps infrared radiation and increases warming potential

### EX: GHG

- **Negative forcing:** reflects solar radiation and decreases warming potential

### EX: some types of brighter clouds and aerosols

### Particulate matter (PM)

- Tiny, solid or liquid particles suspended in air, categorized by size and composition
- Originate from natural sources and human activities, such as combustion
- **PM<sub>2.5</sub>:** 2.5 microns or less in diameter
- **PM<sub>10</sub>:** 10 microns or less in diameter; therefore, includes PM<sub>2.5</sub>
- **Impactors** for PM separate solids from an air sample into different size ranges for analysis
- **Electrostatic precipitators** remove PM from industrial exhaust gases by:
  - Charging particles
  - Collecting them on oppositely charged plates

### Chemical Processes

### Chemical composition of air



### Key atmospheric layer processes

- Roughly 1,340  $W/m^2$  of solar radiation reaches Earth's upper atmosphere
  - 47% is absorbed by Earth's surface
  - 17% is absorbed by the atmosphere
- For every 2,090  $W$  of infrared radiation emitted by the atmosphere, 1,293  $W$  is absorbed at the surface
- For every 1,504  $W$  of infrared radiation from Earth's surface, 1,460  $W$  is absorbed in the atmosphere
- Radiation energy not absorbed by Earth's atmosphere or surface is reflected back to space

### Radiation

### Earth's radiation budget

- Altitude ranges above sea level and temperature ranges:
  - **Troposphere:** sea level (–15°C) to 10–16 km (–56°C)
  - **Stratosphere:** 10–16 km to –50 km (–2°C)
  - **Mesosphere:** –50 km to –85 km (–92°C)
  - **Thermosphere:** –85 km to –500 km (–1,200°C)

# Environmental Chemistry Study Guide

**James Girard**



## **Environmental Chemistry Study Guide:**

**Principles of Environmental Chemistry** James Girard, 2013 Written for science majors who have completed a general chemistry course Principles of Environmental Chemistry Third Edition enables students to understand the underlying chemical processes that are operating in the environment while demonstrating how difficult it is to measure these systems It emphasizes that all living and nonliving parts of our environment are made up of chemicals and that all of the natural processes continuously occurring in the environment involve chemical reactions With this concept of interdependence students begin to see that without some understanding of chemistry it is impossible to fully understand environmental issues such as ozone depletion global warming air and water pollution and the hazards of radioactivity The Third Edition includes a new chapter on Green Chemistry as well as numerous updates throughout to address the changes in the field Key Features Includes a new chapter on Green Chemistry A new key term glossary is now included at the end of the text New feature boxes assess students understanding of chapter material with analytical questions and problems Includes additional chemical equations throughout the text A new electronic student study guide and solutions manual is available with the third edition Instructor s resources include PowerPoint Lecture Outlines answers to end of chapter problems and a testbank A student companion website includes chapter outlines interactive glossary flashcards and weblinks

**Environmental Chemist I** National Learning Corporation, 2020-02 The Environmental Chemist I Passbook R prepares you for your test by allowing you to take practice exams in the subjects you need to study It provides hundreds of questions and answers in the areas that will likely be covered on your upcoming exam including but not limited to Analytical chemistry including techniques equipment and procedures Organization and interpretation of data Laboratory practices techniques and equipment and more

**The Essential Guide to Environmental Chemistry** Georg Schwedt, 2001-12-21 This excellent and most reasonably priced guide is essential reading and a valuable reference source The ROSPA Occupational Safety Health Jnl March 2002 The Essential Guide to Environmental Chemistry outlines the problems and issues facing the environmental chemist throughout the ecosystem Presented as a pocket atlas this useful guide provides a concise overview of environmental pollution in air water and soil as well as strategies for environmental analysis Unique format with text and illustrations on facing pages Clear full colour schematic diagrams making up 50% of the book A must have for undergraduates graduates in this field

**Chemist I (Environmental Control)** National Learning Corporation, 2019-02 The Chemist I Environmental Control Passbook R prepares you for your test by allowing you to take practice exams in the subjects you need to study It provides hundreds of questions and answers in the areas that will likely be covered on your upcoming exam including but not limited to Analytical chemistry including techniques equipment and procedures Organization and interpretation of data Laboratory practices techniques and equipment and more

*Studyguide for Environmental Chemistry by Baird, Colin* Cram101 Textbook Reviews, 2013-05 Never HIGHLIGHT a Book Again Includes all testable terms concepts persons places and events Cram101

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answers on Atmosphere composition air pollutants climatology global warming meteorology ozone depletion and troposphere

**A Guide to Environmental Chemistry** Rainer Roldan Fiscal,2022-12 Environmental chemistry involves the study of biochemical factors that exist in nature It includes a comprehension of how the unpolluted environment functions which naturally existing compounds are available in what amounts and with what impacts Without this it may be difficult to concentrate on the impacts on people to the environment with the discharge of chemical elements It is a multidisciplinary science that notwithstanding chemistry includes physical science agriculture public health sanitary engineering material science etc This volume researches the sources responses transport impacts and purpose of chemical species in the air water and lands and the impact of human activities on different sections like the hydrosphere lithosphere and biosphere The goal of environmental chemistry education is to edify the general population about the significance of protecting our environment and the need to limit human activities causing indiscriminate discharge of contaminants into the environment Currently different environmental factors exist that threaten the existence of humanity on the planet Some environmental chemical issues include the 1952 London smog killing around 4000 individuals the Mediterranean Sea transforming into the Dead Sea during the 1950s incapable of supporting sea life and corrosion of the white Taj Mahal marble in India **Revise As and A2**

**- Chemistry** Rob Ritchie,2008-10 Revise AS A2 Chemistry gives complete study support throughout the two A Level years This Study Guide matches the curriculum content and provides in depth course coverage plus invaluable advice on how to get the best results in the exams *Basics of Environmental Chemistry* Cybellium Ltd,2024-10-26 Designed for professionals students and enthusiasts alike our comprehensive books empower you to stay ahead in a rapidly evolving digital world Expert Insights Our books provide deep actionable insights that bridge the gap between theory and practical application Up to Date Content Stay current with the latest advancements trends and best practices in IT AI Cybersecurity Business Economics and Science Each guide is regularly updated to reflect the newest developments and challenges Comprehensive Coverage Whether you re a beginner or an advanced learner Cybellium books cover a wide range of topics from foundational principles to specialized knowledge tailored to your level of expertise Become part of a global network of learners and professionals who trust Cybellium to guide their educational journey [www.cybellium.com](http://www.cybellium.com) **Environmental**

**Chemistry: Advanced Concepts and Applications** Zhen-Yu Tian,2025-03-08 This book is a comprehensive guide that explores the intricate relationship between chemistry and the environment The book offers a systematic study of various aspects including basic chemical concepts atmospheric chemistry phase interactions water pollution and treatment the atmosphere and its chemistry particles in the atmosphere photochemical smog the geosphere geochemistry and soil chemistry It offers a blend of theoretical explanations practical examples detailed illustrations and tables to facilitate a deeper understanding of the subject matters The book s uniqueness is its ability to simplify complex scientific concepts and present them in an accessible and engaging manner It employs a didactic approach making learning a proactive and

enjoyable process Readers appreciate the in depth exploration of topics such as the law of conservation of matter the role of the atmosphere in safeguarding life on Earth the formation of photochemical smog the evolution of the geosphere and the role of soil colloids in soil chemistry It emphasizes the importance of understanding these concepts to address environmental challenges effectively The key benefit for readers is gaining a comprehensive understanding of environmental chemistry its concepts and its real world applications This book serves as an essential resource for those aiming to gain in depth understanding of the subject and its significance in preserving our planet This makes it particularly appealing to students researchers and professionals interested in environmental sciences

Environmental Chemistry: Key Concepts cybellim Ltd,2024-10-26 Designed for professionals students and enthusiasts alike our comprehensive books empower you to stay ahead in a rapidly evolving digital world Expert Insights Our books provide deep actionable insights that bridge the gap between theory and practical application Up to Date Content Stay current with the latest advancements trends and best practices in IT AI Cybersecurity Business Economics and Science Each guide is regularly updated to reflect the newest developments and challenges Comprehensive Coverage Whether you re a beginner or an advanced learner Cybellium books cover a wide range of topics from foundational principles to specialized knowledge tailored to your level of expertise Become part of a global network of learners and professionals who trust Cybellium to guide their educational journey [www.cybellium.com](http://www.cybellium.com)

**Environmental Chemistry** Teh Fu Yen,1999 This volume begins with a close look at the fundamental equilibrium related processes related to the environmental impact of industrial processes chemical equilibrium water softening precipitation stabilization ion exchange and coagulation Next the book presents detailed coverage of several crucial chemical processes among them disinfection combustion pyrolysis oxidation corrosion and aeration Extensive coverage of biochemical processes biochemical kinetics activated sludge biotreatment and bioconversion and physicochemical processes sedimentation flotation filtration adsorption membrane separation is also included The book concludes with detailed coverage of electromechanical magnetic and sonochemical treatment options A companion volume *Environmental Chemistry Essentials of Environmental Chemistry for Engineering Practice Volume 4A* presents an overview of environmental chemistry in each major envirosphere This book is part of the Prentice Hall PTR Environmental Management and Engineering Series

*A Textbook of Environmental Chemistry* Abhilash E S,2023-12-29 The study of environmental chemistry entails the investigation of the impacts that chemicals have on the air water and soil as well as the ways in which these chemicals influence the health of humans and the environment Environmental chemists are consequently often the chemists who interact with the public the most since the research that they carry out contributes to the formation of judgements that have an impact on all humans Within the scope of this book biological resources or the ways in which they are connected to the physical and chemical features of the environment are investigated The regional as well as worldwide environmental concerns such as pollution of water air soil and noise as well as the kinds of pollution the sources of pollution and the impacts

of pollution on the ecosystem have received the attention and focus that they deserve In addition to providing a more concentrated and individualized explanation of physical mathematical and modelling components that apply to environmental circumstances of concern this book offers a comprehensive and accessible study of phase partitioning and transformation processes It also offers straightforward modelling tools that can quantitatively characterize these processes and how they interact within a specific environmental system The textbook of environmental chemistry is designed to educate students and instructors of environmental sciences environmental chemistry and environmental studies at the graduate postgraduate polytechnic or engineering levels with an essential understanding of the concepts underlying the environment and its chemistry Additionally this book is helpful for students as well as lecturers who are studying general science Applications of Environmental Aquatic Chemistry Eugene R. Weiner,2012-12-07 Professionals and students who come from disciplines other than chemistry need a concise yet reliable guide that explains key concepts in environmental chemistry from the fundamental science to the necessary calculations for applying them Updated and reorganized Applications of Environmental Aquatic Chemistry A Practical Guide Third Edition provides the essential background for understanding and solving the most frequent environmental chemistry problems Diverse and self contained chapters offer a centralized and easily navigable framework for finding useful data tables that are ordinarily scattered throughout the literature Worked examples provide step by step details for frequently used calculations drawing on case histories from real world environmental applications Chapters also offer tools for calculating quick estimates of important quantities and practice problems that apply the principles to different conditions This practical guide provides an ideal basis for self study as well as short courses involving the movement and fate of contaminants in the environment In addition to extensive reorganization and updating the Third Edition includes a new chapter Nutrients and Odors Nitrogen Phosphorus and Sulfur two new appendices Solubility of Slightly Soluble Metal Salts and Glossary of Acronyms and Abbreviations Used in this Book and new material and case studies on remediation stormwater management algae growth and treatment odor control and radioisotopes

**Environmental Chemistry** Stanley E. Manahan,2022-06-19 With clear explanations real world examples and updated ancillary material the 11th edition of Environmental Chemistry emphasizes the concepts essential to the practice of environmental science technology and chemistry The format and organization popular in preceding editions is used including an approach based upon the five environmental spheres and the relationship of environmental chemistry to the key concepts of sustainability industrial ecology and green chemistry The new edition provides a comprehensive view of key environmental issues and significantly looks at diseases and pandemics as an environmental problem influenced by other environmental concerns like climate change Features The most trusted and best selling text for environmental chemistry has been fully updated and expanded once again The author has preserved the basic format with appropriate updates including a comprehensive overview of key environmental issues and concerns New to this important text is material on the threat of

pathogens and disease deadly past pandemics that killed millions recently emerged diseases and the prospects for more environment threats related to disease This outstanding legacy appeals to a wide audience and can also be an ideal interdisciplinary book for graduate students with degrees in a variety of disciplines other than chemistry New Long awaited companion website featuring additional ancillary material

**Chemistry of Environmental Systems** Jeffrey S. Gaffney, Nancy A. Marley, 2019-08-29 A modern guide to environmental chemistry Chemistry of Environmental Systems Fundamental Principles and Analytical Methods offers a comprehensive and authoritative review of modern environmental chemistry discussing the chemistry and interconnections between the atmosphere hydrosphere geosphere and biosphere Written by internationally recognized experts the textbook explores the chemistries of the natural environmental systems and demonstrates how these chemical processes change when anthropogenic emissions are introduced into the whole earth system This important text Combines the key areas of environmental chemistry needed to understand the sources fates and impacts of contaminants in the environment Describes a range of environmental analytical methodologies Explores the basic environmental effects of energy sources including nuclear energy Encourages a proactive approach to environmental chemistry with a focus on preventing future environmental problems Includes study questions at the end of each chapter Written for students of environmental chemistry environmental science environmental engineering geoscience earth and atmospheric sciences Chemistry of Environmental Systems Fundamental Principles and Analytical Methods covers the key aspects and mechanisms of currently identified environmental issues which can be used to address both current and future environmental problems

**Environmental Chemistry** Lucy T. Pryde, 1973

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