About the Book

Welcome to "Environmental Chemistry," a thorough examination of the intricate relationship between chemical processes and the environment. This book explores the fundamental principles, applications, and implications of environmental chemistry, offering insights into the dynamic interplay between human activities and the natural world.
In the opening chapter, "Fundamentals of Environmental Chemistry," readers establish a foundation for understanding environmental systems, including pollutant sources, reactions, and fates.

About the Editors:

Arun Sharma is currently serving as Associate Professor in the department of chemistry at Career Point University, Kota (Rajasthan). His fields of research are electrochemistry, material science, immunosensors, quantum dots and warfare agents. He obtained his Ph.D. in Chemistry from Jiwaji University Gwalior (NAAC A++), in 2016.

Dr. Erum Gull Naz is a famous researcher in theoretical and computational chemistry, specializing in chemical reaction dynamics, rate constants, thermodynamics, and kinetics. She earned her Ph.D. at the prominent Indian Institute of Technology (IIT) in Jodhpur, Rajasthan. Her study also includes organo-physical chemistry and interstellar chemistry, which investigate basic processes that occur on Earth and beyond.

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Ms. Insha Ara, a researcher in theoretical and analytical chemistry, specializing in organic chemistry. She earned her Master of Science at the prominent Career point University in Kota , Raj where she studied many aspects of chemical processes, such as their Analytical and practical and get a Gold medalist in academics and got many certificates in academic

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ENVIRONMENTAL CHEMISTRY

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CP PUBLICATION

ENVIRONMENTAL CHEMISTRY

CAREER POINT

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Published by Career Point Ltd.
CP Tower, Road No.-1, IPIA, Kota (Raj.)
Email : publication@cpil.in

Book No. : CPP-710

Preface

Welcome to "Environmental Chemistry," a thorough examination of the intricate relationship between chemical processes and the environment. This book explores the fundamental principles, applications, and implications of environmental chemistry, offering insights into the dynamic interplay between human activities and the natural world.

In the opening chapter, "Fundamentals of Environmental Chemistry," readers establish a foundation for understanding environmental systems, including pollutant sources, reactions, and fates.

Chapter 2, "The Impact of Various Environmental Pollutants on the Earth's Atmosphere," illuminates diverse pollutants affecting air quality and climate dynamics.

"Thermodynamic Principles and Applications in Engineering," Chapter 3, explores thermodynamics' role in environmental processes and engineering solutions, emphasizing energy considerations in sustainability efforts.

Chapter 4, "Biochemical Kinetics: Exploring Gibbs Free Energy and Enzyme Catalysis," focuses on biological transformations' mechanisms and relevance to environmental systems.

Chapters 5 through 8 delve into atmospheric chemistry, examining processes leading to inorganic and organic particulate matter formation, thermochemical and photochemical reactions, and their implications for atmospheric composition and climate change.

Chapter 9, "Green Chemistry for Water: Sustainable Solutions to Pollution," addresses the nexus between chemistry and water quality, proposing innovative approaches for mitigating pollution and promoting sustainable water management.

Lastly, Chapter 10, "Soil Chemistry," explores chemical dynamics within terrestrial ecosystems, including soil pollution, nutrient cycling, and human activities' impact on soil health.This multidisciplinary journey deepens our understanding of environmental chemistry's role in addressing contemporary challenges and fostering sustainable solutions for our planet's well-being.

We extend our heartfelt thanks to Pramod Maheshwari, Sir, Managing Director and Chairman of Career Point University, Kota, as well as the HOD and Dean for their inspiration and support during the book's development. Gratitude is also expressed to our families for their constant encouragement, and to students and the teaching community for their support. Suggestions to improve the book's quality are welcomed.

Dr. Arun Sharma

Dr. Erum Gull Naz

Dr. Surabhi Singh

Ms. Kriti Tripathi

Ms. Insha Ara

Environmental Chemistry

Syllabus

Unit-I (Dr. Arun)

Stoichiometry, Gibb's energy, Chemical potential, Chemical equilibria, acid-base. reactions Solubility product, solubility of gases in water, the carbonate system, unsaturated and saturated hydrocarbons, Radio nuclides.

Unit -II (Dr. Surabhi)

Classification of elements, chemical speciation, Particles, ions and radicals in the atmosphere. Chemical processes for formation of inorganic and organic particulate matter. Thermochemical and photochemical reactions in the atmosphere

Unit - III (Dr. Erum)

First law of thermodynamics, enthalpy, adiabatic transformations, second law of thermodynamics, Carnot's cycle, entropy.

Unit - IV (Dr. Erum)

Gibbs free energy, chemical potential, phase equilibria, Gibbs Donnan equilibrium, third law of thermodynamics, enzymes catalysis, Michaelis/Menten equation.

Unit - V (Ms. Kriti Tripathi)

Oxygen and ozone chemistry, Chemistry of air pollutants, Photochemical Smog, Chemistry of water, concept of D.O., B.O.D., and C.O.D, water treatment : Sedimentation, Coagulation, Filtration, tertiary and advanced treatment, redox potential. Inorganic and organic components of soil, nitrogen pathways and NPK in soils.

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Dr. Arun Sharma, Dr. Erum Gull Naz

Dr. Surabhi Singh and Ms. Kriti Tripathi

Ms. Insha Ara

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CHAPTER 2

The Impact of Various Environmental Pollutants on the Earth's Atmosphere

Dr. Arun Sharma

ABSTRACT

The "Earth's atmosphere is a complex system that is constantly being influenced by various environmental pollutants. These pollutants can have a significant impact on the atmosphere, leading to changes in air quality, climate, and weather patterns. Some of the most common pollutants include carbon dioxide (CO_2), methane (CH_4), nitrogen oxides (NOx), sulfur dioxide (SO_2), and particulate matter (PM). Carbon dioxide is a greenhouse gas that is released into the atmosphere through the burning of fossil fuels and deforestation. It contributes to global warming and climate change by trapping heat in the atmosphere. Methane is another potent greenhouse gas that is released through agricultural practices, such as rice cultivation and livestock farming. Nitrogen oxides and sulfur dioxide are released through the burning of fossil fuels and industrial processes, and they can lead to the formation of acid rain and smog. Particulate matter is a mixture of solid particles and liquid droplets that can be released through combustion processes and industrial activities. It can lead to respiratory problems and other health issues. Overall, the impact of various environmental pollutants on the Earth's atmosphere is significant and can have far-reaching consequences for the environment" and human health.

Content-

1. Introduction:

The "Earth's atmosphere is a complex system that plays a crucial role in supporting life on our planet. It provides us with the air we breathe, regulates the climate, and protects us from harmful ultraviolet radiation from the sun. However, human activities have led to the release of various pollutants into the atmosphere, which can have significant impacts on air quality, climate, and human health [1].

One of the most significant pollutants in the Earth's atmosphere is carbon dioxide (CO_2). CO_2 is a greenhouse gas that is released into the atmosphere through the burning of fossil fuels, such as coal, oil, and natural gas, as well as deforestation and other land-use changes. It is a major contributor to global warming and climate change, as it traps heat in the atmosphere and leads to rising temperatures, melting ice caps, and more extreme weather events[2]. Another important pollutant is methane (CH_4), which is also a greenhouse gas. Methane is released into the atmosphere through agricultural practices, such as rice cultivation and livestock farming, as well as the production and transport of fossil fuels. It is a more potent greenhouse gas than CO_2, but it has a shorter atmospheric lifetime [3].

Nitrogen oxides (NOx) and sulfur dioxide (SO_2) are also significant pollutants in the Earth's atmosphere. They are released through the burning of fossil fuels and industrial processes, and they can lead to the formation of acid rain and smog. Acid rain can damage ecosystems, harm aquatic life, and corrode buildings and infrastructure, while smog can lead to respiratory problems and other health issues [4].

Particulate matter (PM) is another important pollutant in the Earth's atmosphere. It is a mixture of solid particles and liquid droplets that can be released through combustion processes, such as the burning of fossil fuels and biomass, as well as industrial activities, construction, and agriculture. PM can have a range of health effects, including respiratory problems, heart disease, and premature death [5].

Overall, environmental pollutants have a significant impact on the Earth's atmosphere, and they can have far-reaching consequences for air quality, climate, and human health. It is important to reduce our emissions of these pollutants and to develop sustainable solutions to mitigate their impacts on the environment and human" health.

2. The Carbonate System

The carbonate system is a key component of the Earth's carbon cycle and plays a crucial role in regulating the pH of the oceans and the atmosphere. It consists of a series of chemical reactions involving carbon dioxide (CO_2), water (H_2O), and carbonate ions ($CO_{3^\wedge 2-}$), bicarbonate ions ($HCO_{3^\wedge -}$), and carbonic acid (H_2CO_3).

The carbonate system is a dynamic system that is constantly in flux, with carbon dioxide being exchanged between the atmosphere, oceans, and terrestrial ecosystems. In the atmosphere, carbon dioxide is present in the form of a gas and is released through the burning of fossil fuels, deforestation, and other human activities [6]. In the oceans, carbon dioxide is dissolved in seawater and can react with water to form carbonic acid, which can then dissociate into bicarbonate and carbonate ions. These ions can then react with calcium ions (Ca^2+) to form calcium carbonate ($CaCO_3$), which is the primary component of marine shells and coral reefs [7].

The carbonate system plays a crucial role in regulating the pH of the oceans, which is important for the health of marine organisms and ecosystems. When carbon dioxide dissolves in seawater, it forms carbonic acid, which can lower the pH of the oceans and make them more acidic. This can have negative impacts on marine organisms, such as corals, shellfish, and plankton, which rely on calcium carbonate for their shells and skeletons. Ocean acidification can also disrupt the balance of the carbonate system and lead to the dissolution of calcium carbonate, which can further exacerbate the problem [8].

The carbonate system also plays a crucial role in the global carbon cycle, which is the process by which carbon is exchanged between the atmosphere, oceans, and terrestrial ecosystems. Carbon dioxide is absorbed by plants during photosynthesis and released back into the atmosphere through respiration and decomposition. It is also absorbed by the oceans, where it can react with water to form carbonic acid and carbonate ions. This process helps to regulate the amount of carbon dioxide in the atmosphere and plays a crucial role in regulating the Earth's climate [9].

Overall, the carbonate system is a complex and dynamic system that plays a crucial role in regulating the pH of the oceans, the global carbon cycle, and the health of marine organisms and ecosystems. It is important to understand the carbonate system and its interactions with the environment in order to develop sustainable solutions to mitigate the impacts of climate change and ocean acidification [10].

3. Unsaturated And Saturated Hydrocarbons

"Hydrocarbons are organic compounds that consist of only hydrogen and carbon atoms. They are classified into two main categories: saturated and unsaturated hydrocarbons. The difference between these two types of hydrocarbons lies in the types of bonds between the carbon atoms. Saturated hydrocarbons, also known as alkanes, are hydrocarbons that contain only single bonds between the carbon atoms [11]. The general formula for saturated hydrocarbons is C_nH_{2n+2}, where n is the number of carbon atoms in the molecule. Saturated hydrocarbons are relatively stable and unreactive, and they are commonly found in natural gas, petroleum, and other fossil fuels. Examples of saturated hydrocarbons include methane (CH_4), ethane (C_2H_6), propane (C_3H_8), and butane (C_4H_{10})."

"Unsaturated hydrocarbons, on the other hand, contain one or more double or triple bonds between the carbon atoms. The general formula for unsaturated hydrocarbons is C_nH_{2n}, where n is the number of carbon atoms in the molecule. Unsaturated hydrocarbons are more reactive than saturated hydrocarbons due to the presence of the double or triple bonds, which can undergo additional reactions with other molecules. Examples of unsaturated hydrocarbons include ethylene (C_2H_4), propylene (C_3H_6), acetylene (C_2H_2), and benzene (C_6H_6).

Unsaturated hydrocarbons can be further classified into two subcategories: alkenes and alkynes. Alkenes are hydrocarbons that contain one or more double bonds between the carbon atoms, while alkynes are hydrocarbons that contain one or more triple bonds between the carbon atoms [12]. The general formula for alkenes is C_nH_{2n}, where n is the number of carbon atoms in the molecule, and the general formula for alkynes is C_nH_{2n-2}, where n is the number of carbon atoms in the molecule.

Unsaturated hydrocarbons are important in organic chemistry because they can undergo a wide range of reactions, including addition reactions, substitution reactions, and elimination reactions. These reactions can be used to synthesize a variety of organic compounds, including polymers, pharmaceuticals, and agrochemicals".

"In summary, saturated hydrocarbons contain only single bonds between the carbon atoms and are relatively stable and unreactive, while unsaturated hydrocarbons contain one or more double or triple bonds between the carbon atoms and are more reactive. Unsaturated hydrocarbons can be further classified into alkenes and alkynes based on the types of bonds present. Unsaturated hydrocarbons are important in organic chemistry because they can undergo a wide range of reactions and can be used to synthesize a variety of organic" compounds [13].

4. Harmful Radionuclides In The Environment

"Harmful radionuclides are radioactive isotopes of elements that can pose a threat to human health and the environment due to their ability to emit ionizing radiation. These radionuclides can be naturally occurring or man-made, and they can be released into the environment through a variety of sources, including nuclear power plants, medical facilities, and industrial processes [14-17].

One of the most well-known harmful radionuclides is radon-222, which is a naturally occurring radioactive gas that is produced by the decay of uranium in the Earth's crust. Radon-222 is the second leading cause of lung cancer in the United States, and it can enter homes and buildings through cracks in the foundation, gaps around pipes, and other openings. Radon-222 can also be released into the atmosphere through the burning of fossil fuels and other human activities [18].

Another harmful radionuclide is iodine-131, which is a man-made radioactive isotope that is used in nuclear medicine and as a tracer in medical imaging. Iodine-131 is a beta emitter, which means that it can cause damage to cells and tissues when it is ingested or inhaled. Iodine-131 is also a gamma emitter, which means that it can penetrate the body and cause damage to internal organs [19].

Cesium-137 is another harmful radionuclide that is produced by nuclear fission in nuclear reactors and nuclear weapons testing. Cesium-137 is a gamma emitter, which means that it can penetrate the body and cause damage to internal organs. Cesium-137 is also a beta emitter, which means that it can cause damage to cells and tissues when it is ingested or inhaled [20].

Strontium-90 is a man-made radioactive isotope that is produced by nuclear fission in nuclear reactors and nuclear weapons testing. Strontium-90 is a beta emitter, which means that it can cause damage to cells and tissues when it is ingested or inhaled. Strontium-90 is also a gamma emitter, which means that it can penetrate the body and cause damage to internal organs [21].

Plutonium-239 is a man-made radioactive isotope that is produced by nuclear fission in nuclear reactors and nuclear weapons testing. Plutonium-239 is an alpha emitter, which means that it can cause damage to cells and tissues when it is ingested or inhaled. Plutonium-239 is also a gamma emitter, which means that it can penetrate the body and cause damage to internal" organs [22].

Overall, harmful radionuclides can pose a threat to human health and the environment due to their ability to emit ionizing radiation [23]. These radionuclides can be naturally occurring or man-made, and they can be released into the environment through a variety of sources, including nuclear power plants, medical facilities, and industrial processes. It is important to monitor and regulate the release of these radionuclides into the environment in order to protect human health and the environment.

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