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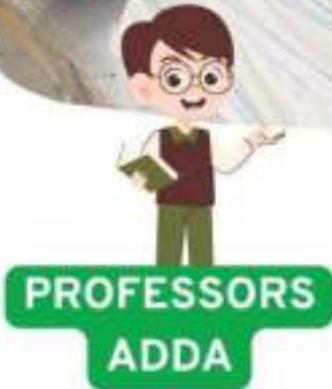


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ENVIRONMENTAL SCIENCE "THINKER TOOL KIT"

Thinker #1: Rachel Carson (1907–1964)



1. **Introduction:**

An American marine biologist, writer, and conservationist, Rachel Carson is celebrated for advancing the global environmental movement. Her work highlighted the dangers of synthetic pesticides, leading to significant changes in environmental

policy and public awareness.

2. Major Contributions:

- **Catalyzing the Environmental Movement:** Her book *Silent Spring* was instrumental in launching the contemporary environmental movement by exposing the hazards of the pesticide DDT.
- **Challenging Chemical Industry Practices:** She accused the chemical industry of spreading disinformation and public officials of accepting industry claims unquestioningly, prompting a nationwide re-evaluation of pesticide use.
- **Influencing Policy:** Her work led to a nationwide ban on DDT for agricultural use and inspired the creation of the U.S. Environmental Protection Agency (EPA).

3. Key Concepts:

- **Bioaccumulation:** Carson popularized the concept of how pesticides and other toxins concentrate in organisms' bodies as they move up the food chain, causing harm to wildlife and humans.
- **Ecological Interconnection:** She emphasized that all parts of an ecosystem are interconnected and that harming one part can have far-reaching, unintended consequences.
- **Precautionary Principle:** While not coining the term, her work embodies its core idea—that

action should be taken to prevent harm even if cause-and-effect relationships are not fully established scientifically.

4. **Key Books/Works:**

- *Under the Sea Wind* (1941)
- *The Sea Around Us* (1951)
- *The Edge of the Sea* (1955)
- *Silent Spring* (1962)

Thinker #2: Eugene P. Odum (1913–2002)



1. **Introduction:**

An American biologist at the University of Georgia, Eugene Odum is widely considered the "father of modern ecology." He pioneered the concept of the

ecosystem as a central organizing principle in ecological studies and advocated for a holistic, integrated approach to environmental science.

2. Major Contributions:

- **Ecosystem Ecology:** He championed the study of ecosystems as whole units, focusing on energy flow, nutrient cycling, and productivity. This is a core concept in Unit III of the syllabus. ¹
- **Bridging Ecology and Economics:** Odum sought to integrate ecological principles with economic valuations, arguing for the economic value of natural ecosystems and their services.
- **Educating Ecologists:** His textbook, *Fundamentals of Ecology*, became the standard text for generations of ecologists, shaping the field for decades.

3. Key Concepts:

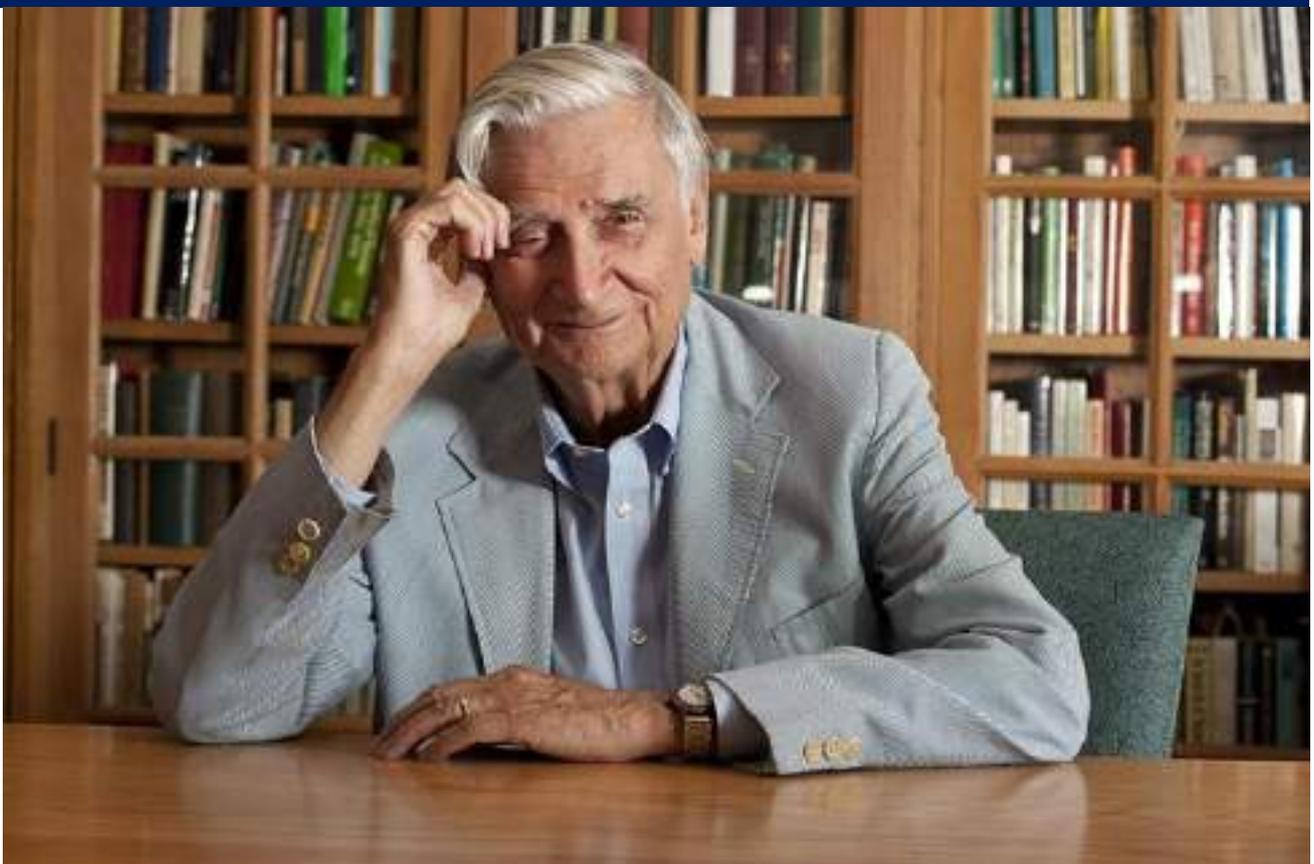
- **Homeostasis in Ecosystems:** Odum applied the concept of homeostasis (stable equilibrium) to ecosystems, explaining how they self-regulate to maintain stability. ²
- **Energy Flow Models:** He developed models to illustrate how energy flows through ecosystems, from producers to consumers and decomposers, a fundamental concept outlined in the syllabus. ³

Ecological Succession: He provided a comprehensive framework for understanding how ecological communities change over time, moving from simple to more complex states. ⁴⁴

4. Key Books/Works:

- *Fundamentals of Ecology* (1953)
- *Ecology* (1963)
- *Basic Ecology* (1983)
- *Ecology and Our Endangered Life-Support Systems* (1989)

Thinker #3: E. O. Wilson (1929–2021)



1. Introduction:

Edward O. Wilson was a highly influential American biologist, naturalist, and writer, often called the "father of sociobiology" and the "father of biodiversity." His work has profoundly shaped our understanding of evolution, ecology, and the importance of conserving life on Earth.

2. Major Contributions:

- **Theory of Island Biogeography:** Co-developed with Robert H. MacArthur, this theory explains how the number of species on an island is determined by factors like island size and distance from the mainland. It is foundational to conservation biology.
- **Advocacy for Biodiversity:** Wilson was a world-leading advocate for the conservation of biodiversity. He popularized the term and articulated the moral and scientific urgency of preventing species extinction. 5
- **Founding Sociobiology:** He proposed that social behaviors in animals, including humans, have an evolutionary and biological basis, a controversial but highly influential idea.

3. Key Concepts:

- **Biophilia:** Wilson's hypothesis that humans possess an innate tendency to seek connections

with nature and other forms of life.

- **Biodiversity**: While he didn't invent the word, he gave it prominence, defining it and explaining its critical importance for ecosystem stability and human well-being. 6
- **Consilience**: The idea that there is a unity of all knowledge, and that insights from different disciplines (e.g., biology, social sciences, humanities) can and should be linked.

4. Key Books/Works:

- *The Theory of Island Biogeography* (1967, with Robert H. MacArthur)
- *Sociobiology: The New Synthesis* (1975)
- *Biophilia* (1984)
- *The Diversity of Life* (1992)

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Thinker #4: Gro Harlem Brundtland (1939–Present)



1. Introduction:

A Norwegian physician, diplomat, and politician, Gro Harlem Brundtland served as the Prime Minister of Norway and Director-General of the World Health Organization. She is most famous in environmental science for chairing the World Commission on Environment and Development (WCED).

2. Major Contributions:

- **Chairing the Brundtland Commission:** She led the WCED, which produced the landmark 1987 report *Our Common Future*.

- **Defining Sustainable Development:** The Brundtland Report provided the most widely accepted definition of sustainable development, a core concept in Unit I of the syllabus. ⁷
- **Linking Environment and Development:** The commission's work formally linked environmental concerns with social and economic development on the global stage, arguing that one cannot be achieved without the other.

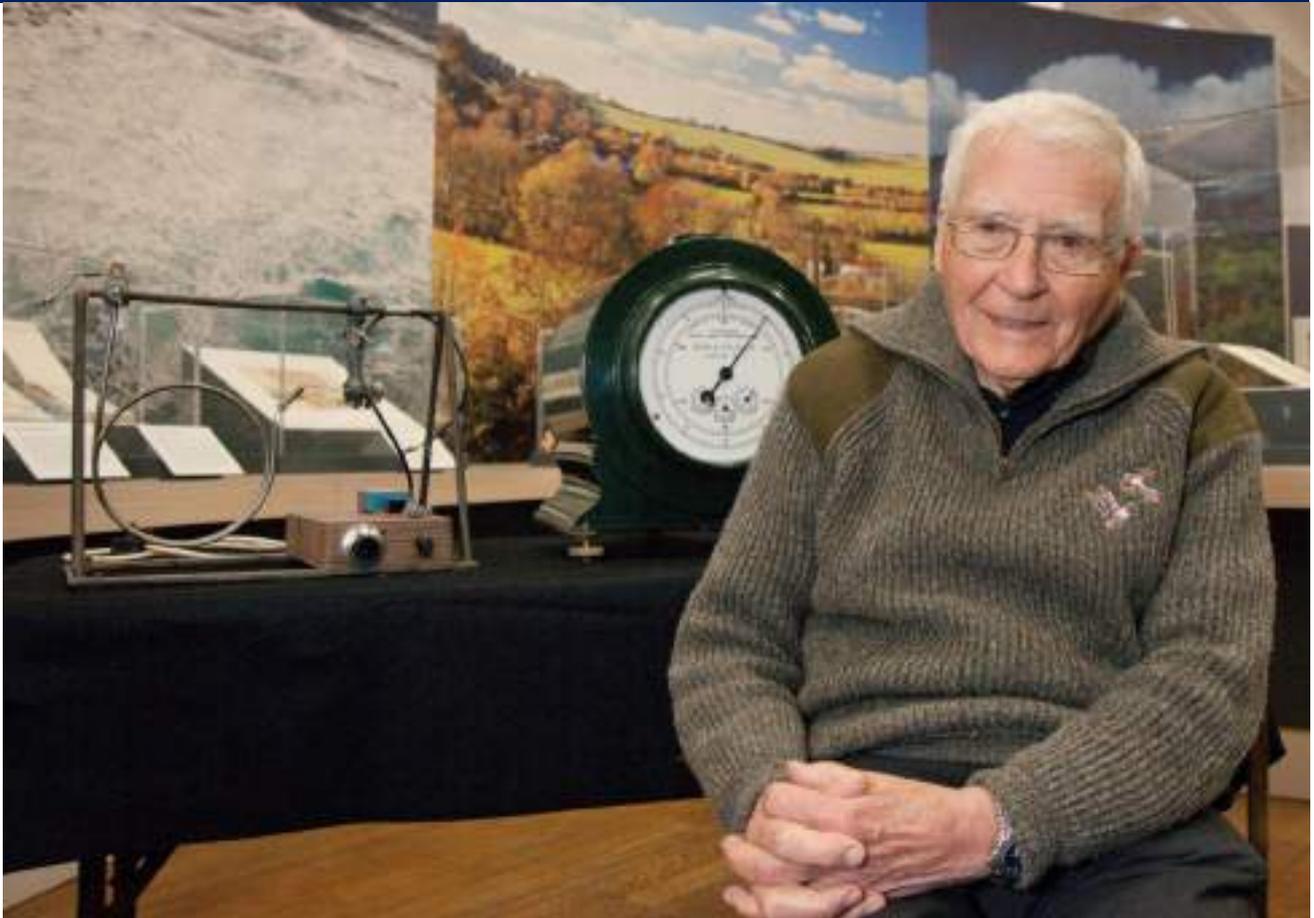
3. Key Concepts:

- **Sustainable Development:** The report defined this as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." ⁸ This is central to modern environmental policy.
- **Intergenerational Equity:** The concept emphasizes our responsibility to future generations, ensuring they inherit a healthy planet with adequate resources.
- **Global Interdependence:** The report stressed that environmental problems like climate change and biodiversity loss are global in nature and require international cooperation to solve.

4. Key Books/Works:

- *Our Common Future* (1987, as Chair of the WCED)

Thinker #5: James Lovelock (1919–2022)



1. Introduction:

An independent British scientist, environmentalist, and futurist, James Lovelock was best known for proposing the Gaia hypothesis. His work presented a novel, holistic view of the Earth as a self-regulating superorganism, which has deeply influenced Earth system science.

2. Major Contributions:

- **Developing the Gaia Hypothesis:** Lovelock, with Lynn Margulis, formulated the idea that life on Earth collectively maintains the planet's

conditions (like temperature and atmospheric composition) to be suitable for life.

- **Inventing the Electron Capture Detector (ECD):** This highly sensitive device was crucial for detecting CFCs and other pollutants in the atmosphere, providing the data that led to the discovery of the ozone hole.
- **Advocacy on Climate Change:** He was an early and vocal advocate for recognizing the severity of climate change, arguing that Gaian systems were being pushed beyond their limits.

3. Key Concepts:

- **Gaia Hypothesis:** The theory that the Earth's biosphere, atmosphere, oceans, and soil constitute a complex interacting system that can be thought of as a single organism. It highlights the interconnectedness of Earth's physical and biological components.
- **Earth System Science:** The Gaia hypothesis was a catalyst for this interdisciplinary field, which studies the Earth as an integrated system of land, water, air, and life.
- **Self-Regulation:** A core tenet of the Gaia hypothesis is that the Earth system has feedback mechanisms that keep environmental conditions within a habitable range.

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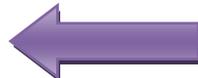
4. Key Books/Works:

- *Gaia: A New Look at Life on Earth* (1979)
- *The Ages of Gaia* (1988)
- *The Revenge of Gaia* (2006)
- *Novacene: The Coming Age of Hyperintelligence* (2019)

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Unit I: Fundamentals of Environmental Sciences

- Q:** What is Environmental Science? **A:** Interdisciplinary study of environment and human interactions.
- Q:** What is a core principle of environmental science? **A:** Interconnectedness of natural systems.
- Q:** What is the scope of environmental science? **A:** Covers natural processes, human impacts, and solutions.
- Q:** What gas makes up most of the atmosphere? **A:** Nitrogen (N₂).
- Q:** What is the second most abundant atmospheric gas? **A:** Oxygen (O₂).
- Q:** What are the layers of the atmosphere from lowest to highest? **A:** Troposphere, Stratosphere, Mesosphere, Thermosphere, Exosphere.
- Q:** What atmospheric layer contains most weather phenomena? **A:** Troposphere.
- Q:** What is the ozone layer located within? **A:** Stratosphere.

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9. **Q:** What defines the hydrosphere? **A:** All water on Earth.
10. **Q:** What percentage of Earth's water is freshwater? **A:** ~2.5-3%.
11. **Q:** Where is most freshwater stored? **A:** Glaciers and ice caps.
12. **Q:** What is the rigid outer layer of Earth? **A:** Lithosphere.
13. **Q:** What makes up the lithosphere? **A:** Crust and upper mantle.
14. **Q:** What is the biosphere? **A:** The sum of all ecosystems; where life exists.
15. **Q:** What is the First Law of Thermodynamics? **A:** Energy conservation (cannot be created or destroyed).
16. **Q:** What is the Second Law of Thermodynamics? **A:** Entropy increases in isolated systems.
17. **Q:** What is entropy? **A:** A measure of disorder or randomness.
18. **Q:** Name the three types of heat transfer. **A:** Conduction, Convection, Radiation.
19. **Q:** How is heat primarily transferred in fluids (liquids/gases)? **A:** Convection.
20. **Q:** What is the principle used to track inputs

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- and outputs in a system? **A:** Material balance.
21. **Q:** What principle assumes mass is conserved in a closed system? **A:** Mass balance.
22. **Q:** What is atmospheric pressure? **A:** Force exerted by the weight of air.
23. **Q:** How does atmospheric pressure generally change with altitude? **A:** Decreases.
24. **Q:** What is the standard atmospheric pressure at sea level (in mb)? **A:** 1013.25 mb.
25. **Q:** What is temperature? **A:** Measure of kinetic energy of molecules.
26. **Q:** What is precipitation? **A:** Any form of water falling from clouds.
27. **Q:** What is humidity? **A:** Amount of water vapor in the air.
28. **Q:** What is relative humidity? **A:** Ratio of current water vapor to maximum possible at that temperature.
29. **Q:** What is mixing ratio? **A:** Mass of water vapor per unit mass of dry air.
30. **Q:** What is saturation mixing ratio? **A:** Maximum mixing ratio at a given temperature and pressure.
31. **Q:** What is radiation in meteorology? **A:** Energy transfer via electromagnetic waves

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(e.g., solar radiation).

32. **Q:** What instrument measures wind velocity?

A: Anemometer.

33. **Q:** What is the adiabatic lapse rate for dry air? **A:** $\sim 9.8^{\circ}\text{C}/\text{km}$.

34. **Q:** What is the environmental lapse rate? **A:** Actual rate of temperature decrease with altitude in the atmosphere.

35. **Q:** What graphical tool shows wind speed and direction frequency? **A:** Windroses.

36. **Q:** What describes the reciprocal influence between humans and nature? **A:** Interaction between Earth, Man and Environment.

37. **Q:** What is the study of geographic distribution of plants and animals? **A:** Biogeography.

38. **Q:** Name one major biogeographic realm. **A:** Palearctic, Nearctic, Afrotropical, Neotropical, Indomalayan, Australasian, Oceanian, Antarctic.

39. **Q:** How many agro-climatic zones does India have? **A:** 15.

40. **Q:** What is the definition of sustainable development? **A:** Meets present needs without compromising future generations.

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41. **Q:** What report popularized sustainable development? **A:** Brundtland Report (Our Common Future, 1987).
42. **Q:** What are examples of renewable resources? **A:** Solar, wind, biomass, water.
43. **Q:** What are examples of non-renewable resources? **A:** Coal, oil, natural gas, minerals.
44. **Q:** What is resource assessment? **A:** Evaluation of the quantity and quality of natural resources.
45. **Q:** What technology gathers information about Earth from a distance? **A:** Remote Sensing.
46. **Q:** What are the basic principles of remote sensing? **A:** Energy source, atmospheric interaction, target interaction, sensor, data processing.
47. **Q:** What part of the electromagnetic spectrum is commonly used in remote sensing? **A:** Visible, Infrared, Microwave.
48. **Q:** What is GIS? **A:** Geographic Information System.
49. **Q:** What does GIS allow for? **A:** Capture, storage, manipulation, analysis, management, and presentation of spatial data.

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50. **Q:** What is digital image processing in remote sensing? **A:** Computer-based manipulation of digital images for enhancement and analysis.
51. **Q:** What is ground truthing? **A:** On-site data collection to verify remote sensing interpretations.
52. **Q:** Name an application of remote sensing in land use planning. **A:** Urban sprawling analysis, land cover mapping.
53. **Q:** How is remote sensing used in forestry? **A:** Forest cover mapping, deforestation monitoring, biomass estimation.
54. **Q:** How is GIS used in waste management? **A:** Landfill site selection, waste collection route optimization.
55. **Q:** How can remote sensing aid in climate change studies? **A:** Monitoring ice melt, sea-level rise, deforestation, temperature anomalies.
56. **Q:** What is the purpose of environmental education? **A:** To create awareness, knowledge, attitudes, skills, and participation for environmental protection.
57. **Q:** What are environmental ethics? **A:** Moral principles governing human interaction with

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the natural environment.

58. **Q:** What is "Deep Ecology"? **A:** A philosophy asserting inherent value of all living things, not just their utility to humans.
59. **Q:** What is the composition of dry air (excluding N₂ & O₂)? **A:** Argon (0.93%), Carbon Dioxide (0.04%), trace gases.
60. **Q:** What atmospheric layer filters most UV radiation? **A:** Stratosphere (via ozone layer).
61. **Q:** What is the general temperature trend in the troposphere with increasing altitude? **A:** Decreases.
62. **Q:** What is the general temperature trend in the stratosphere with increasing altitude? **A:** Increases.
63. **Q:** What causes temperature to increase in the stratosphere? **A:** Absorption of UV radiation by ozone.
64. **Q:** What is the smallest of the Earth's spheres by volume? **A:** Biosphere.
65. **Q:** What is the most active zone for chemical and biological processes? **A:** Biosphere.
66. **Q:** What type of energy transfer requires a medium? **A:** Conduction and Convection.
67. **Q:** What type of energy transfer can occur

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through a vacuum? **A:** Radiation.

68. **Q:** What is latent heat? **A:** Heat absorbed or released during a phase change.

69. **Q:** What is sensible heat? **A:** Heat that causes a change in temperature.

70. **Q:** What is the unit of pressure commonly used in meteorology? **A:** Millibars (mb) or Pascals (Pa).

71. **Q:** What is the relationship between temperature and relative humidity (holding water vapor constant)? **A:** Inverse (as T increases, RH decreases).

72. **Q:** What is the dew point temperature? **A:** The temperature at which air becomes saturated and condensation begins.

73. **Q:** What is solar radiation? **A:** Electromagnetic radiation emitted by the Sun.

74. **Q:** What is terrestrial radiation? **A:** Longwave radiation emitted by Earth.

75. **Q:** What is albedo? **A:** The reflectivity of a surface.

76. **Q:** What is insolation? **A:** Incoming solar radiation.

77. **Q:** What drives wind? **A:** Pressure differences (Pressure Gradient Force).

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78. **Q:** What is the Coriolis Effect? **A:** Deflecting force due to Earth's rotation, affecting winds and currents.
79. **Q:** What is the difference between lapse rate and adiabatic lapse rate? **A:** Lapse rate is observed, adiabatic is theoretical for a rising/falling air parcel.
80. **Q:** What is a common method for classifying agro-climatic zones? **A:** Based on rainfall, temperature, and soil type.
81. **Q:** What is the concept of carrying capacity related to? **A:** Natural resource assessment, population ecology.
82. **Q:** What is 'digital image processing' essential for in remote sensing? **A:** Extracting meaningful information from raw satellite data.
83. **Q:** Name a common band combination used for vegetation study in remote sensing. **A:** Near Infrared (NIR) and Red.
84. **Q:** What is urban sprawling? **A:** Unplanned expansion of urban areas into rural land.
85. **Q:** How can remote sensing help in natural resource management? **A:** Mapping, monitoring, and inventory of resources.
86. **Q:** What is the role of GIS in land use

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UNIT – 1

Fundamentals of Environmental Sciences



UNIT – 1

Fundamentals of Environmental Sciences

Definition

Environmental science is the study of the interactions between the physical, chemical, and biological components of nature. As such, it is a multidisciplinary science: it involves a number of disciplines like geology, hydrology, soil sciences, plant physiology, and ecology.

Environmental scientists may have training in more than one discipline; for example, a geochemist has expertise in both geology and chemistry. Most often, the multidisciplinary nature of environmental scientists' work comes from collaborations they foster with other scientists from complementary research fields.

Environmental science and engineering are evolving endeavors. When public and scientific interests began to accelerate in the second half of the twentieth century, pollutants of any type and in any environmental compartment were addressed on a contaminant-by-contaminant control basis. Each law and regulation addressed a single compartment. As evidence, the U.S. Congress passed the Clean Air Act for air, the Clean Water Act for water, and so on. During the 1980s, this command and control paradigm continued, but added at least an acknowledgment for the need to prevent pollution and to minimize the volume and toxicity of wastes. All of these, along with subsequent life cycle approaches, have been aimed at reducing risks to acceptable levels.

Importance of Environmental Science

At this current time, the world around us is changing at a very rapid pace. Some changes are beneficial, but many of the changes are causing damage to our planet. The field of environmental science is a valuable resource for learning more about these changes and how they affect the world we live in.

Let's examine a major change that is currently occurring and its relationship to environmental science. The large change is the dramatic increase in the number of humans on earth. For most of human history, the population has been less than a million people, but the current population has skyrocketed to over seven billion people. This equals out to seven thousand times more people!

Due to this increase in the human population, there has also been an increase in pressure on the natural resources and ecosystem services that we rely on for survival. Natural resources include a variety of substances and energy sources that we take from the environment and use. Natural resources can be divided into renewable and nonrenewable resources. Renewable natural resources are substances that can be replenished over a period of time, such as sunlight, wind, soil, and timber. On the other hand, nonrenewable natural resources are substances that are in finite supply and will run out. Nonrenewable resources include minerals and crude oils.

Due to the increase in the human population, natural resources are being used up at a more rapid rate than in the past. Although renewable natural resources can be replenished, when they are used too rapidly, they cannot be replenished fast enough to meet human demand. Even worse, when nonrenewable natural resources are used too rapidly, they become closer to running out completely and being gone forever.





Natural resources have been referred to as the 'merchandise' produced by the environment, and in this respect, ecosystem services are the 'facilities' that we rely on to help produce the merchandise. Ecosystem services are the environment's natural processes that provide us with the resources we need to support life. Common ecosystem services include water and air purification, nutrient cycling, climate regulation, pollinating of plants, and the recycling of waste. Just like some natural resources, ecosystem services are also limited and can be used up if not regulated.

Now, let's tie it together and think about population growth and its influence on both natural resources and ecosystem services. As the human population increases and natural resources and ecosystem services are used rapidly and potentially degraded, the future of humans on earth is in jeopardy. This is one major example of why environmental science is important and valuable.

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Some important definitions of environment are as under:





1. According to Boring, 'A person's environment consists of the sum total of the stimulation which he receives from his conception until his death.' Indicating that environment comprises various types of forces such as physical, intellectual, mental, economical, political, cultural, social, moral and emotional.
2. Douglas and Holland defined that 'The term environment is used to describe, in aggregate, all the external forces, influences and conditions, which affect the life, nature, behavior and the growth, development and maturity of living organisms'.

Scope of environment:

The environment consists of four segments of the earth namely atmosphere, hydrosphere, lithosphere and biosphere:

1. **Atmosphere:** The Atmosphere forms a distinctive protective layer about 100 km thick around the earth. A blanket of gases called the atmosphere surrounds the earth and protects the surface of earth from the Sun's harmful, ultraviolet rays. It sustains life on the earth. It also regulates temperature, preventing the earth from becoming too hot or too cold. It saves it from the hostile environment of outer space. The atmosphere is composed of nitrogen and oxygen besides, argon, carbon dioxide and trace gases.
2. The atmosphere has a marked effect on the energy balance at the surface of the Earth. It absorbs most of the cosmic rays from outer space and a major portion of the electromagnetic radiation from the sun. It transmits only ultraviolet, visible, near infrared radiation (300 to 2500 nm) and radio waves. (0.14 to 40 m) while filtering out tissue-damaging ultra-violet waves below about 300 nm.
3. **Hydrosphere:** The Hydrosphere comprises all types of water resources oceans, seas, lakes, rivers, streams, reservoirs, polar icecaps, glaciers, and ground water. Oceans represent 97% of the earth's water and about 2% of the water resources is locked in the polar icecaps and glaciers. Only about 1% is available as fresh water as surface water in rivers, lakes, streams, and as ground water for human use.
4. **Lithosphere:** Lithosphere is the outer mantle of the solid earth. It consists of minerals occurring in the earth's crusts and the soil e.g. minerals, organic matter, air and water.
5. **Biosphere:** Biosphere indicates the realm of living organisms and their interactions with environment, viz atmosphere, hydrosphere and lithosphere.
6. The scope of environmental studies is very wide and it deals with many areas like i) Conservation of natural resources, ii) ecological aspects, iii) pollution of the surrounding natural resources, iv) controlling the pollution, v) social issues connected to it, and vi) impacts of human population on the environment.

Elements of environment

Environment is constituted by the interacting systems of physical, biological and cultural elements inter-related in various ways, individually as well as collectively. These elements are:

(1) Physical elements

Physical elements are space, landforms, water bodies, climate, soils, rocks and minerals. They determine the variable character of the human habitat, its opportunities as well as limitations.

(2) Biological elements

Biological elements such as plants, animals, microorganisms and men constitute the biosphere.

(3) Cultural elements





Cultural elements such as economical, social and political elements are essentially man-made features, which make the cultural background.

Environment studies: importance

The environment studies make us aware about the importance of protection and conservation of our mother earth and about the destruction due to the release of pollution into the environment. The increase in human and animal population, industries and other issues make the survival cumbersome. A great number of environment issues have grown in size and make the system more complex day by day, threatening the survival of mankind on earth. Environment studies have become significant for the following reasons:

1. Environment Issues are being of Global:

It has been well recognised that environment issues like global warming and ozone depletion, acid rain, marine pollution and biodiversity are not merely national issues but are global issues and hence require international efforts and cooperation to solve them.

2. Development and Environment:

Development leads to Urbanization, Industrial Growth, Telecommunication and Transportation Systems, Hi-tech Agriculture and Housing etc. However, it has become phased out in the developed world. The North intentionally moves their dirty factories to South to cleanse their own environment. When the West developed, it did so perhaps in ignorance of the environmental impact of its activities. Development of the rich countries of the world has undesirable effect on the environment of the entire world.

3. Explosive Increase in Pollution

World census reflects that one in every seven persons in this planet lives in India. Evidently with 16 per cent of the world's population and only 2.4 per cent of its land area, there is a heavy pressure on the natural resources including land. Agricultural experts have recognized soil health problems like deficiency of micronutrients and organic matter, soil salinity and damage of soil structure.

4. Need for an Alternative Solution

It is essential, specially for developing countries to find alternative paths to an alternative goal. We need a goal as under: **Principles** and **Practices** provides the scientific principles, concepts, applications, and methodologies required to understand the interrelationships of the natural world, identify and analyze environmental problems both natural and manmade, evaluate the relative risks associated with these problems, and examine alternative solutions (such as renewable energy sources) for resolving and even preventing them. Frank R. Spellman and Melissa Stoudt introduce the science of the environmental mediums of air, water, soil, and biota to undergraduate students.

Principles and Practices brings these topics together under several major themes, including

1. How energy conversions underlie all ecological processes
2. How the earth's environment functions as an integrated system
3. How human activities alter natural systems
4. How the role of culture, social, and economic factors is vital to the development of solutions
5. How human survival depends on practical ideas of stewardship and sustainability

What is atmosphere?

We all know that earth is a unique planet due to the presence of life. The air is one among the necessary conditions for the existence of life on this planet. The air is a mixture of several gases and it





encompasses the earth from all sides. The air surrounding the earth is called the atmosphere.

- Atmosphere is the air surrounding the earth.
- The atmosphere is a mixture of different gases. It contains life-giving gases like Oxygen for humans and animals and carbon dioxide for plants.
- It envelops the earth all round and is held in place by the gravity of the earth.
- It helps in stopping the ultraviolet rays harmful to the life and maintains the suitable temperature necessary for life.
- Generally, atmosphere extends up to about 1600 km from the earth's surface. However, 99 % of the total mass of the atmosphere is confined to the height of 32 km from the earth's surface.

Composition of the atmosphere

- The atmosphere is made up of different gases, water vapour and dust particles.
- The composition of the atmosphere is not static and it changes according to the time and place.

Gases of the atmosphere

- The atmosphere is a mixture of different types of gases.
- Nitrogen and oxygen are the two main gases in the atmosphere and 99 percentage of the atmosphere is made up of these two gases.
- Other gases like argon, carbon dioxide, neon, helium, hydrogen, etc. form the remaining part of the atmosphere.
- The portion of the gases changes in the higher layers of the atmosphere in such a way that oxygen will be almost negligible quantity at the heights of 120 km.
- Similarly, carbon dioxide (and water vapour) is found only up to 90 km from the surface of the earth.

Carbon dioxide:

- Carbon dioxide is meteorologically a very important gas.
- It is transparent to the incoming solar radiation (insolation) but opaque to the outgoing terrestrial radiation.
- It absorbs a part of terrestrial radiation and reflects back some part of it towards the earth's surface.
- Carbon dioxide is largely responsible for the greenhouse effect.
- When the volume of other gases remains constant in the atmosphere, the volume of the carbon dioxide has been rising in the past few decades mainly because of the burning of fossil fuels. This rising volume of carbon dioxide is the main reason for global warming.

Ozone gas:

- Ozone is another important component of the atmosphere found mainly between 10 and 50 km above the earth's surface.
- It acts as a filter and absorbs the ultra-violet rays radiating from the sun and prevents them from reaching the surface of the earth.
- The amount of ozone gas in the atmosphere is very little and is limited to the ozone layer found in the stratosphere.

Water vapour

- Gases form of water present in the atmosphere is called water vapour.
- It is the source of all kinds of precipitation.





- The amount of water vapour decreases with altitude. It also decreases from the equator (or from the low latitudes) towards the poles (or towards the high latitudes).
- Its maximum amount in the atmosphere could be up to 4% which is found in the warm and wet regions.
- Water vapour reaches in the atmosphere through evaporation and transpiration. Evaporation takes place in the oceans, seas, rivers, ponds and lakes while transpiration takes place from the plants, trees and living beings.
- Water vapour absorbs part of the incoming solar radiation (insolation) from the sun and preserves the earth's radiated heat. It thus acts like a blanket allowing the earth neither to become too cold nor too hot.
- Water vapour also contributes to the stability and instability in the air.

Dust particles

- Dust particles are generally found in the lower layers of the atmosphere.
- These particles are found in the form of sand, smoke-soot, oceanic salt, ash, pollen, etc.
- Higher concentration of dust particles is found in subtropical and temperate regions due to dry winds in comparison to equatorial and polar regions.
- These dust particles help in the condensation of water vapour. During the condensation, water vapour gets condensed in the form of droplets around these dust particles and thus clouds are formed.

Structure of the atmosphere

The atmosphere can be divided into five layers according to the diversity of temperature and density. They are:

1. Troposphere
2. Stratosphere
3. Mesosphere
4. Thermosphere (Ionosphere)
5. Exosphere

Troposphere

- It is the lowermost layer of the atmosphere.
- The height of this layer is about 18 km on the equator and 8 km on the poles.
- The thickness of the troposphere is greatest at the equator because heat is transported to great heights by strong convectional currents.
- Troposphere contains dust particles and water vapour.
- This is the most important layer of the atmosphere because all kinds of weather changes take place only in this layer.
- The air never remains static in this layer. Therefore this layer is called 'changing sphere' or troposphere.
- The environmental temperature decreases with increasing height of the atmosphere. It decreases at the rate of 1 degree Celsius for every 165 m of height. This is called Normal Lapse Rate.
- The zone separating troposphere from the stratosphere is known as tropopause.
- The air temperature at the tropopause is about - 80 degree Celsius over the equator and about - 45 degree Celsius over the poles. The temperature here is nearly constant, and hence, it is called tropopause.

Stratosphere

- Stratosphere is found just above the troposphere.





- It extends up to a height of 50 km.
- The temperature remains almost the same in the lower part of this layer up to the height of 20 km. After this, the temperature increases slowly with the increase in the height. The temperature increases due to the presence of ozone gas in the upper part of this layer.
- Weather related incidents do not take place in this layer. The air blows horizontally here. Therefore this layer is considered ideal for flying of aircraft.
- The upper limit of the stratosphere is known as stratopause.
- One important feature of stratosphere is that it contains a layer of ozone gas.
- The relative thickness of the ozone layer is measured in Dobson Units.
- It is mainly found in the lower portion of the stratosphere, from approximately 20 to 30 km above the earth's surface.
- It contains a high concentration of ozone (O₃) in relation to other parts of the atmosphere.
- It is the region of the stratosphere that absorbs most of the sun's ultra-violet radiations.

Mesosphere

- It is the third layer of the atmosphere spreading over the stratosphere.
- It extends up to a height of 80 km.
- In this layer, the temperature starts decreasing with increasing altitude and reaches up to – 100 degree Celsius at the height of 80 km.
- Meteors or falling stars occur in this layer.
- The upper limit of the mesosphere is known as mesopause.

Thermosphere

- This layer is located between 80 and 400 km above the mesopause.
- It contains electrically charged particles known as ions, and hence, it is known as the **ionosphere**.
- Radio waves transmitted from the earth are reflected back to the earth by this layer and due to this, radio broadcasting has become possible.
- The temperature here starts increasing with heights.

Exosphere

- The exosphere is the uppermost layer of the atmosphere.
- Gases are very sparse in this sphere due to the lack of gravitational force. Therefore, the density of air is very less here.

Hydrosphere

A hydrosphere is the total amount of water on a planet. The hydrosphere includes water that is on the surface of the planet, underground, and in the air. A planet's hydrosphere can be liquid, vapor, or ice.

On Earth, liquid water exists on the surface in the form of oceans, lakes and rivers. It also exists below ground— as groundwater, in wells and aquifers. Water vapor is most visible as clouds and fog.

The frozen part of Earth's hydrosphere is made of ice: glaciers, ice caps and icebergs. The frozen part of the hydrosphere has its own name, the cryosphere.

Water moves through the hydrosphere in a cycle. Water collects in clouds, then falls to Earth in the form of rain or snow. This water collects in rivers, lakes and oceans. Then it evaporates into the atmosphere to start the cycle all over again. This is called the water cycle.

The Structure and Composition of Hydrosphere





Out of the 72% of water found in the Earth:

- 96.5% are Oceans
 - 3.5% are freshwater resources
- Fresh water distribution:
- Ice: 1.762%
 - Groundwater: 1.7%
 - Surface Fresh Water: 0.014%
 - Atmosphere and soil: 0.002%

Lithosphere

A lithosphere is the rigid, outermost shell on Earth. It is composed of the crust and the portion of the upper mantle that behaves elastically on time scales of thousands of years or greater. The outermost shell of a rocky planet, the crust, is defined on the basis of its chemistry and mineralogy.

This includes the crust and the uppermost mantle, which constitute the hard and rigid outer layer of the Earth. The uppermost part of the lithosphere that chemically reacts to the atmosphere, hydrosphere and biosphere through the soil forming process is called the pedosphere.

Lithosphere composition

The earth's crust is not a homogeneous substance, It has different layers of rocks including sedimentary rocks on top, granitic and metamorphic rocks in the middle and basaltic rocks on the bottom.

The earth's crust also consists of several large dynamic tectonic plates. These tectonic plates move slowly but continuously at an average rate of around 10 cm. Considering this, there was no Atlantic Ocean, and North America and Europe together were one continent 180 million years ago. The Atlantic Ocean came into being because of the drifting apart of the Eurasian and North America plates.

Types of lithosphere

These are two types:

Oceanic, which is associated with oceanic crust and exists in the ocean basins.

Continental, which is associated with continental crust.

Structure

The oceanic lithosphere is composed of the lithospheric mantle and the oceanic crust with mainly gabbroic and basaltic rocks formed at the oceanic spreading centers. The thickness of the oceanic lithosphere increases with increasing distance to the spreading center because new lithospheric material is continuously added at the base of the lithosphere by conductive cooling. At about 1200 °C, the partially molten asthenospheric material gets completely solid and is converted into lithospheric mantle. The density of the solid material increases a little from 3.25 g/cm³ for the asthenosphere to about 3.30 g/cm³ since thermal contraction makes it denser than the asthenospheric material. As a consequence the mean density of the oceanic lithosphere as an entirety (lithospheric mantle plus oceanic crust) increases with the thickness of the lithospheric mantle. At a certain point depending on the spreading velocity and the distance from the spreading center, the stable layering changes into instability with a slightly denser lithosphere on top of the lighter asthenosphere. This configuration applies for lithosphere older than 80–90 myrs in relation to the onset of spreading at a mid-oceanic ridge. With an unstable layering, a new subduction zone may be initiated.





ed spontaneously by gravitational downwelling of old oceanic lithosphere. The continental lithosphere is composed of the lithospheric mantle and the continental crust with a large variety of rocks formed during the entire Earth's history. Continental crust is unsubductable because of its little density. Although the lower part is made up of gabbroic/basaltic and granulitic rocks, the mean density of the entire continental crust is about 2.7 g/cm³ and thus significantly lower than oceanic crust. Rocks of the upper portion of the continental crust were formed mostly by processes that changed the primary composition of the parent material. Basaltic magmas differentiate into lighter melts, forming felsic (word combines letters from feldspar and silica), plutonic, and volcanic rocks (e.g., granite, granodiorite, and, resp., rhyolite, dacite, etc.) that are enriched in silica and light elements (O, Al, Na, K). Erosion, transportation, and sedimentation result in the formation of sedimentary rocks, and, caused by continuous sedimentation and orogenic processes, the rocks may be metamorphosed by elevated pressure and temperatures. During the Earth's history, the amount of continental crust has been increasing, and the growth appears to have occurred in spurts of increased activity corresponding to the preservation of juvenile continental crust due to the formation of supercontinents (Condie, 2000). It is assumed that basaltic eruptions of superplumes and the subsequent magmatic and erosional processing of the basaltic protolith are the most important contribution of crustal growth (Albarède, 1998). The thickness of the lithosphere depends on the plate tectonic setting. Normally, an evolved continental lithosphere has a thickness of about 90–120 km; oceanic lithosphere is slightly thinner with 70–90 km. This is mainly the result of the different thicknesses of oceanic vs. continental crust. Oceanic crust has a thickness of 5 to mostly 8 km, whereas an evolved continental crust has an average thickness of 30–35 km. Abnormal thin lithosphere exists in continental rifts, where the continental lithosphere may be less than 50 km thick, and at mid-oceanic spreading centers, where new oceanic lithosphere is formed. In these narrow zones, the lithosphere is confined to a thin layer (2–5 km) of oceanic crust only. The oceanic lithosphere is getting thicker with increasing distance from the spreading ridge. Continental lithosphere may be substantially thickened during orogenic processes. The collision of two continental plates results in the development of large mountain ranges such as the Himalayas or the Alps where overthrusting of large portions of the continental crust occurs. This may result in the thickening of the continental lithosphere to more than 200 km and a doubling of the crustal part of the lithosphere which may sum up to more than 75 km in maximum. This yields an isostatically instable situation which over long periods of time will be compensated by surface erosion and isostatic rebound until the average thickness of continental crust of 30–35 km is restored.

Biosphere

All living components of the Earth. All plants animals and microbes and their surroundings are known as biosphere.

Environment has two components- Abiotic(physical and inorganic)and Biotic(organic).

The structure of Biosphere has three components: Abiotic, Biotic and energy components.

- I. **Abiotic Components:** It consists of all non-living elements which are essential for the survival of all living organisms. It has lithosphere, atmosphere and hydrosphere. Mineral nutrients, gases and water are three basic requirements of organic life.
- II. **Biotic Components:** It includes Plants, animals and human beings to make biotic components of environment. there are three sub-system:
 - Plants: They are very important part of biotic components. They are primary producers of food through process of photosynthesis. They are called autotrophs.
 - Animals: They are main consumers of plant produce, hence known as Heterotrophs. They





use organic matter produced by plants and transform the food into energy (used in growth and development).

- Micro-organism: They act as decomposers of dead plants and animals.

III. Energy : It is vital component of biosphere which is essential for reproduction and generation of all biological life on Earth.

Structure and composition of biosphere

Ecological System: Interactions of a particular group of organisms with abiotic factors within a particular habitat resulting in clearly defined energy flows and material cycles on land, water & air.

Ecology: Derived from Greek word 'oikos' meaning house and 'logy' means science. Ernst Haeckel used the term in 1869 for the first time. The study of interactions between life forms and physical environment is known as science of ecology. So, it is the study of abiotic and biotic interactions.

Habitat: It is the totality of physical and chemical factors that constitute the general environment.

Ecosystem: System of biotic and abiotic components inter-related and interact with each. Therefore, an ecosystem involves interactions among different components and flow of energy among these components.

Ecological adaptation: Plants and animals species have got adapted through evolution to different types of environmental conditions.

Laws of thermodynamics the first law

The first law of thermodynamics basically states that energy is conserved; it can neither be created nor destroyed, just changed from one form to another, "*The total amount of energy in an isolated system is conserved.*" The energy in a system can be converted to heat or work or other things, but you always have the same total that you started with.

As an analogy, think of energy as indestructible blocks. If you have 30 blocks, then whatever you do to or with the blocks you will always have 30 of them at the end. You can't destroy them, only move them around or divide them up, but there will always be 30. Sometimes you may lose one or more, but they still have to be taken account of because Energy is Conserved.

The second law

This is possibly the most famous (among scientists at least) and important laws of all science. It states; "*The entropy of the universe tends to a maximum.*" In other words Entropy either stays the same or gets bigger, the entropy of the universe can never go down.

The problem is, this isn't always true. If you take our example of 4 atoms in a box then all of them being in one corner is a highly ordered system and so will have a low entropy, and then over time they'll move around become more disordered and increasing the entropy. But there is nothing stopping them all randomly moving back to the corner. It's incredibly unlikely, but not actually impossible.

If you look at the problem in terms of phase space you can see that over time it's more likely you'll move into a bigger box, which means higher entropy, but there's no actual barrier stopping you moving back into a smaller box.

The third law





The third law provides an absolute reference point for measuring entropy, saying that *“As the temperature of a system approaches absolute zero (-273.15°C , 0 K), then the value of the entropy approaches a minimum.”* The value of the entropy is usually 0 at 0K, however there are some cases where there is still a small amount of residual entropy in the system

Heat Transfer Methods– Conduction, Convection and Radiation Introduction

Equally as interesting as the effects of heat transfer on a system are the methods by which this occurs. Whenever there is a temperature difference, heat transfer occurs. Heat transfer may occur rapidly, such as through a cooking pan, or slowly, such as through the walls of a picnic ice chest. We can control rates of heat transfer by choosing materials (such as thick wool clothing for the winter), controlling air movement (such as the use of weather stripping around doors), or by choice of color (such as a white roof to reflect summer sunlight). So many processes involve heat transfer, so that it is hard to imagine a situation where no heat transfer occurs. Yet every process involving heat transfer takes place by only three methods:

1. **Conduction** is heat transfer through stationary matter by physical contact. (The matter is stationary on a macroscopic scale—we know there is thermal motion of the atoms and molecules at any temperature above absolute zero.) Heat transferred between the electric burner of a stove and the bottom of a pan is transferred by conduction.
2. **Convection** is the heat transfer by the macroscopic movement of a fluid. This type of transfer takes place in a forced-air furnace and in weather systems, for example.
3. Heat transfer by **radiation** occurs when microwaves, infrared radiation, visible light, or another form of electromagnetic radiation is emitted or absorbed. An obvious example is the warming of the Earth by the Sun. A less obvious example is thermal radiation from the human body.

Mass and Energy Transfer across various Interfaces

Mass transfer of gaseous components from rising bubbles to the ambient liquid can be described based on continuum mechanical sharp-interface balances of mass, momentum and species mass. In this context, the standard model consists of the two-phase Navier-Stokes equations for incompressible fluids with constant surface tension, complemented by reaction-advection-diffusion equations for all constituents, employing Fick's law. This standard model is inconsistent with the continuity equation, the momentum balance and the second law of thermodynamics. The present paper reports on the details of these severe shortcomings and provides thermodynamically consistent model extensions which are required to capture various phenomena which occur due to the multi-physics of interfacial mass transfer. In particular, we provide a simple derivation of the interface Maxwell-Stefan equations which does not require a time scale separation, while the main contribution is to show how interface concentrations and interface chemical potentials mediate the influence on mass transfer of a transfer component exerted by the change in interface energy due to an adsorbing surfactant.

Law of Conservation of Mass: Mass can neither be created nor destroyed (except in nuclear reactions).

Because of this, we can write equations called "mass balances" or "material balances". Any process being studied must satisfy balances on the total amount of material, on each chemical component, and on individual atomic species. Later in the course, we'll use the **Law of Conservation of Energy** (1st Law of Thermodynamics) to write similar balance equations for energy.

Material Balances





Material balances are typically used to describe how much material is available for each species, using variables such as the numbers of moles or the concentrations, while a heat balance is used to describe how much thermal energy is available, using variables such as the heat or the temperature.

Meteorological parameters

Variables, such as pressure, temperature, wind strength, humidity, etc. from which conclusions as to the forthcoming weather are drawn.

Meteorological measurements for weather forecasting and climatology have been carried out on a regular basis for centuries.

However, the data acquired can only be evaluated and interpreted after having statistically recorded medium-term and long-term atmospheric conditions.

Nowadays, transport and communications such as ground, air and sea traffic could not be maintained without these data, which are mainly being collected from measurements and observations in the atmosphere close to the ground (the Boundary Layer). The main meteorological parameters in this field are:

- Wind speed and direction
- Air temperature
- Air pressure
- Air humidity
- Precipitation
- Haze and contents of the air
- Solar and terrestrial radiation

These parameters are also significant for such issues as air pollution, avalanche warning, sun simulation, renewable energy industry, agriculture, forestry, water supply and distribution, town and regional planning. For example, the evaluation and interpretation of gas emission measurements is only possible in comparison with meteorological data acquired concurrently.

The structure of the atmosphere close to the ground is extremely important for the local climate. Knowing the solar radiation as well as the air humidity and air temperature is necessary to evaluate chemical reactions of pollutants in the air.

All meteorological parameters are subject to short-term variations, normally caused by turbulences within the atmosphere. All

meteorological parameters are influenced by solar radiation, directly or indirectly, and this results in typical daily or yearly trends.

In order to be able to evaluate these typical trends it is necessary to compute the mean values from the actual ones measured over a specific period. For some meteorological parameters it is quite easy to understand their daily cycle. For example, the temperature cycle is normally a simple curve with a minimum value shortly after sunrise and a maximum in the early afternoon. The yearly cycle of a meteorological parameter can be determined by making daily measurements. The average yearly cycle within a climatic region is normally determined by making measurements over a minimum of 30 years.





Of course, meteorological measurements have to be made outside. This means that the sensors and associated electronics must be designed to withstand the local climatic conditions, which may be extreme, from deserts to Antarctica.

Within the atmosphere close to the ground the temporal and spatial characteristics of radiation values are influenced by the characteristics of the ground surface. The most influential factors affecting the received radiation at any particular location are:

- Location on the earth
- Date and time
- Precipitation (cloud, fog, rain, snow)
- Constriction of the horizon (field of view)
- Air pollution (aerosols and gasses)
- Albedo

Due to the physical effects mentioned above it is sometimes not sufficient for many application fields to just measure the 'Global Radiation' coming from all around the measurement location. It may also be necessary to measure the 'Direct Radiation' coming only from the sun and/or the 'Diffuse Radiation' (not coming directly from the sun). The 'Radiation Balance' of incoming to outgoing radiation in the short-wave and long-wave may also be required.

Before reaching the ground the solar radiation is influenced by our atmosphere and its physical characteristics and an essential parameter is the absorption in different wavelength ranges. Albedo is affected by surfaces with different reflection characteristics, such as water, ice, snow, stone, grass, crops or woodland.

Pressure

Pressure is defined as force per unit area. It is usually more convenient to use pressure rather than force to describe the influences upon fluid behavior. The standard unit for pressure is the Pascal, which is a Newton per square meter.

For an object sitting on a surface, the force pressing on the surface is the weight of the object, but in different orientations it might have a different area in contact with the surface and therefore exert a different pressure.

There are many physical situations where pressure is the most important variable. If you are peeling an apple, then pressure is the key variable: if the knife is sharp, then the area of contact is small and you can peel with less force exerted on the blade. If you must get an injection, then pressure is the most important variable in getting the needle through your skin: it is better to have a sharp needle than a dull one since the smaller area of contact implies that less force is required to push the needle through the skin.

When you deal with the pressure of a liquid at rest, the medium is treated as a continuous distribution of matter. But when you deal with a gas pressure, it must be approached as an average pressure from molecular collisions with the walls.

Pressure in a fluid can be seen to be a measure of energy per unit volume by means of the definition of work. This energy is related to other forms of fluid energy by the Bernoulli equation.

Pressure as Energy Density





Pressure in a fluid may be considered to be a measure of energy per unit volume or energy density. For a force exerted on a fluid, this can be seen from the definition of pressure: The most obvious application is to the hydrostatic pressure of a fluid, where pressure can be used as energy density alongside kinetic energy density and potential energy density in the Bernoulli equation.

The other side of the coin is that energy densities from other causes can be conveniently expressed as an effective "pressure". For example, the energy density of solvent molecules which leads to osmosis is expressed as osmotic pressure. The energy density which keeps a star from collapsing is expressed as radiation pressure.

Temperature

It is a physical property that underlies the common notions of hot and cold. Celsius scale is used for most temperature measuring purposes.

Temperature is a measure of how hot or cold something is; specifically, a measure of the average **kinetic energy** of the particles in an object, which is a type of energy associated with motion. But how hot is hot, and how cold is cold? The terms hot and cold are not very scientific terms. If we really want to specify how hot or cold something is, we must use temperature. For instance, how hot is melted iron? To answer that question, a physical scientist would measure the temperature of the liquid metal. Using temperature instead of words, like hot or cold, reduces confusion.

The solar radiation absorbed by the atmosphere and the heat emitted by the earth increase the air temperature. The sensible heat of the surrounding air transfers energy to the crop and exerts as such a controlling influence on the rate of evapotranspiration. In sunny, warm weather the loss of water by evapotranspiration is greater than in cloudy and cool weather.

Relative humidity

While the energy supply from the sun and surrounding air is the main driving force for the vaporization of water, the difference between the water vapour pressure at the evaporating surface and the surrounding air is the determining factor for the vapour removal. Well-watered fields in hot dry arid regions consume large amounts of water due to the abundance of energy and the desiccating power of the atmosphere. In humid tropical regions, notwithstanding the high energy input, the high humidity of the air will reduce the evapotranspiration demand. In such an environment, the air is already close to saturation, so that less additional water can be stored and hence the evapotranspiration rate is lower than in arid regions.

The ratio of the vapor pressure to the saturation vapor pressure with respect to water. This quantity is alternatively defined by the World Meteorological Organization as the ratio of the mixing ratio to the saturation mixing ratio.

Humidity is the amount of water vapor in the air. If there is a lot of water vapor in the air, the humidity will be high. The higher the humidity the wetter it feels outside.

On the weather reports, humidity is usually explained as relative humidity. Relative humidity is the amount of water vapor actually in the air, expressed as a percentage of the maximum amount of water vapor the air can hold at the same temperature. Think of the air at a chilly -10 degrees Celsius (14 degrees Fahrenheit). At that temperature, the air can hold, at most, 2.2 grams of water per cubic meter. So if there are 2.2 grams of water per cubic meter when it's -10 degrees Celsius outside, we're at an uncomfortable 100 percent relative humidity. If there was 1.1 grams of water in the air at -10 degrees Celsius, we're at 50 percent relative humidity.





When humidity is high, the air is so clogged with water vapor that there isn't room for much else. If you sweat when it's humid, it can be hard to cool off because your sweat can't evaporate into the air like it needs to. Humidity is blamed for all kinds of negative things, including mold in your house (usually the bathroom, where it's wet a lot of the time), as well as malfunctions in regular household electronics. Moisture from humid air settles, or condenses, on electronics. This can interrupt the electric current, causing a loss of power. Computers and television sets can lose power like this if not protected from the effects of humidity.

Living with humidity is easier with the aid of a dehumidifier, which sucks moisture out of the air.

Precipitations

Precipitation is water released from clouds in the form of rain, freezing rain, sleet, snow, or hail. It is the primary connection in the water cycle that provides for the delivery of atmospheric water to the Earth. Most precipitation falls as rain.

The essential difference between a precipitation particle and a cloud particle is one of size. An average raindrop has a mass equivalent to about one million cloud droplets. Because of their large size, precipitation particles have significant falling speeds and are able to survive the fall from the cloud to the ground.

The transition from a cloud containing only cloud droplets to one containing a mixture of cloud droplets and precipitation particles involves two basically different steps: the formation of incipient precipitation elements directly from the vapour state and the subsequent growth of those elements through aggregation and collision with cloud droplets. The initial precipitation elements may be either ice crystals or chemical-solution droplets.

Development of precipitation through the growth of ice crystals depends on the fact that cloud droplets can freeze spontaneously at temperatures below about -40°C , or -40°F . (The reduction of cloud droplets to temperatures below the normal freezing point is termed supercooling.) Within supercooled clouds, ice crystals may form through sublimation of water vapour on certain atmospheric dust particles known as sublimation nuclei. In natural clouds, ice crystals form at temperatures colder than about -15°C ($+5^{\circ}\text{F}$).

The exact temperature of ice crystal formation depends largely on the physical-chemical nature of the sublimation nucleus.

Once ice crystals have formed within a supercooled cloud, they continue to grow as long as their temperature is colder than freezing. The rates of growth depend primarily upon the

temperature and degree of vapour saturation of the ambient air. The crystals grow at the expense of the water droplets. In favourable conditions—e.g., in a large, rapidly growing cumulus cloud—an ice crystal will grow to a size of about 0.13 millimetre (0.005 inch) in three to five minutes after formation. At this size, the rate of growth through sublimation slows down, and further growth is largely through aggregation and collision with cloud droplets.

Small solution drops are also important as incipient precipitation particles. The atmosphere contains many small particles of soluble chemical substances. The two most common are sodium chloride swept up from the oceans and sulfate-bearing compounds formed through gaseous reactions in the atmosphere. Such particles, called condensation nuclei, collect water because of their hygroscopic nature and, at relative humidities above about 80 percent, exist as solution droplets. In





tropical maritime air masses, the number of condensation nuclei is often very large. Clouds forming in such air may develop a number of large solution droplets long before the tops of the clouds reach temperatures favourable to the formation of ice crystals.

Regardless of whether the initial precipitation particle is an ice crystal or a droplet formed on a condensation nucleus, the bulk of the growth of the precipitation particle is through the mechanisms of collision and coalescence. Because of their larger size, the incipient precipitation elements fall faster than do cloud droplets. As a result, they collide with the droplets lying in their fall path.

The rate of growth of a precipitation particle through collision and coalescence is governed by the relative sizes of the particle and the cloud droplets in the fall path that are actually hit by the precipitation particle and the fraction of these droplets that actually coalesce with the particle after collision.

Mixing ratio

The Mixing ratio (also called specific humidity) is a strange phrase but comes nearest to our intuitive understanding of concentration - the amount of one component in a mixture. The mixing ratio of water vapour in air is the weight of water vapour mixed into a given weight of dry air. The unit is kg/kg. This is the vertical axis of the psychrometric chart. There are two common uses for the mixing ratio. In meteorology the mixing ratio is useful for tracing the properties of vast air masses as they rise or fall in the atmosphere. The mixing ratio of a discrete blob of moist air does not change with varying atmospheric pressure and temperature as it moves in the atmosphere. In the more down to earth science of air conditioning, the mixing ratio is useful in calculations involving air as the transporter of water vapour through ducts to control the room humidity. Air is also the transporter of heat to control the room temperature. Calculations of the energy used in air conditioning have to combine the thermal properties of both air and water vapour.

The mixing ratio requires knowing the total air pressure. In practice, the mixing ratio is calculated from measurement of the relative humidity and the temperature, assuming a typical air pressure of 101 kPa, at sea level.

Saturation Mixing Ratio

The saturation mixing ratio (w_s) is the ratio of the mass of water vapor (M_v) to the mass of dry air (M_d) in a parcel of air at saturation. In other words w_s is the maximum amount of water vapor that a parcel can hold without condensation.

$w_s = M_v / M_d$ The saturation mixing ratio is expressed in parts per thousand, usually grams of water vapor per kilogram of dry air.

To find the saturation mixing ratio for a given pressure on the plotted sounding, read the value, either directly or by interpolation, of the saturation mixing-ratio line that crosses the T curve at that pressure.

Tables of Saturation Mixing Ratios

Table for Fahrenheit Temperature



Temperature (°F) Or Dew Point Temperature (°F)	Saturation Mixing Ratio (g / kg) Or Mixing Ratio (g / kg)
-40	0.12
-30	0.21
-20	0.35
-10	0.58
0	0.94
10	1.52
15	1.89
20	2.34
25	2.88
30	3.54
35	4.33
40	5.28
45	6.40
50	7.74
55	9.32
60	11.19
65	13.38
70	15.95
75	18.94
80	22.43
85	26.48
90	31.16
95	36.56
100	43.22

Table for Celsius Temperature	
Temperature (°C) Or Dew Point Temperature (°C)	Saturation Mixing Ratio (g / kg) Or Mixing Ratio (g / kg)
-40	0.1
-30	0.3
-20	0.8
-10	1.8
0	3.8
5	5.4
10	7.6
15	10.6
20	14.7
25	20.1

30	27.2
35	36.6
40	49.0

Radiation

The evapotranspiration process is determined by the amount of energy available to vaporize water. Solar radiation is the largest energy source and is able to change large quantities of liquid water into water vapour. The potential amount of radiation that can reach the evaporating surface is determined by its location and time of the year. Due to differences in the position of the sun, the potential radiation differs at various latitudes and in different seasons. The actual solar radiation reaching the evaporating surface depends on the turbidity of the atmosphere and the presence of clouds which reflect and absorb major parts of the radiation. When assessing the effect of solar radiation on evapotranspiration, one should also bear in mind that not all available energy is used to vaporize water. Part of the solar energy is used to heat up the atmosphere and the soil profile.

Wind Speed

Wind Speed (Wind Velocity) is an air moving from high to low pressure, usually due to changes in temperature that measures over the land surface at a height of 10 m above ground level. Wind is the horizontal movement of air and is specified by its speed and direction. The normal unit of wind speed is the knot, and the wind direction is measured relative to true north (not magnetic north) and is reported from where the wind is blowing. The Wind Speed is defined as the two minute average speed in knots. The gust speed and direction are defined by the maximum three second average wind speed occurring in any period. A gale is defined as a surface wind of mean speed of 34-40 knots, averaged over a period of ten minutes.

Adiabatic Lapse rate

The rate at which atmospheric temperature decreases with increasing altitude in conditions of thermal equilibrium.

The adiabatic lapse rate is the rate at which the temperature of an air parcel changes in response to the compression or expansion associated with elevation change, under the assumption that the process is adiabatic, i.e., no heat exchange occurs between the given air parcel and its surroundings.

Adiabatic lapse rate is the rate of change of temperature of an air parcel as it moves upwards through the atmosphere rapidly. $\gamma = -dT/dz$ The "rapid" condition means that the air parcel moves fast enough that there is no considerable exchange of heat with the surrounding air (i.e., adiabatic).

This change in temperature is due to the fact that as you move upward through the atmosphere, the atmospheric pressure decreases, causing the air parcel to expand. Since this expansion is adiabatic, the work required for expansion is taken from the internal energy of the parcel, causing it to cool down.

When the air is dry (no moisture content), the adiabatic lapse rate is given by the formula $\gamma_{dry} = g/c_p$. This amounts to about 9.80C/km.

Environmental Lapse Rate



The ELR (Environmental Lapse Rate) is the actual rate at which the ambient temperature changes with height.

The lapse rate of nonrising air—commonly referred to as the normal, or environmental, lapse rate—is highly variable, being affected by radiation, convection, and condensation; it averages about 6.5 °C per kilometre (18.8 °F per mile) in the lower atmosphere (troposphere) Environmental Lapse Rate The environmental lapse rate is the rate at which temperature changes in the vertical in the troposphere, as observed by an upwards moving radiosonde. This varies greatly from day to day. When this lapse rate is averaged out for all places and times, it is called the Standard (or Average) Lapse Rate, which is around 3.0F/1000 ft. It's important to keep in mind that this lapse rate is determined by a vertically moving radiosonde. The air itself is not moving up or down.

Dry Adiabatic Lapse Rate

The lapse rate that occurs in a vertically moving air parcel in which no condensation is occurring. The temperature change is related to the expansional cooling (compressional warming) that occurs when the air moves upward (downward). It is entirely determined by the pressure distribution in the atmosphere in question. For earth's atmosphere, in the troposphere, for example, the pressure is 200 mb at the top and 1000 mb at the bottom. Thus, the dry adiabatic lapse rate is constant, 5.5F/1000 ft (1C/100m). This is known as the dry adiabatic lapse rate because no heat is added or subtracted from the moving air parcel (adiabatic) and no moisture is condensing (dry).

Wet Adiabatic Lapse Rate

The lapse rate that occurs in a vertically moving air parcel in which condensation is occurring. For example, although an upwards moving air parcel will always experience expansional cooling as a dominant effect, a certain amount of heating offsets that cooling due to latent heat release associated with condensation. This latent heat release is dependent upon temperature and pressure, so the wet adiabatic rate is not a constant. It averages around 3.5F/1000 ft in the lower troposphere.

Wind roses

The wind rose is the time honored method of graphically presenting the wind conditions, direction and speed, over a period of time at a specific location. To create a wind rose, average wind direction and wind speed values are logged at a site, at short intervals, over a period of time, e.g. 1 week, 1 month, or longer. The collected wind data is then sorted by wind direction so that the percentage of time that the wind was blowing from each direction can be determined. Typically the wind direction data is sorted into twelve equal arc segments, 30° each segment, in preparation for plotting a circular graph in which the radius of each of the twelve segments represents the percentage of time that the wind blew from each of the twelve 30° direction segments. Wind speed data can be superimposed on each direction segment to indicate, for example, the average wind speed when the wind was blowing from that segment's direction and the maximum wind speed during the logging period.

Wind rose, map diagram that summarizes information about the wind at a particular location over a specified time period. A wind rose was also, before the use of magnetic compasses, a guide on mariners' charts to show the directions of the eight principal winds. The modern wind rose used by meteorologists gives the percentage of the time the wind blows from each direction during the observation period; it sometimes shows the strengths of these winds and the percentage of the time calm air or light winds are observed. This wind rose usually has eight radiating lines, whose lengths are proportional to wind frequency, and shows wind strength by the thickness of the lines or by feathers attached to them. The frequency of calm or nearly calm air is given as a number in the cen-





tre.

Interaction between Earth

Environmental science studies the interactions between the physical, chemical, and biological components of the environment, including their effects on all types of organisms. Earth science (also known as geoscience), is an inclusive term for all sciences related to Earth (geology, meteorology, oceanography, etc). Although environmental and earth science cover essentially the same material, environmental science places greater emphasis on the biological realm, while earth science places greater emphasis on the physical realm.

Environmental and earth science study the interactions of four major systems or “spheres”.

The geosphere consists of the core, mantle and crust of the Earth.

The atmosphere contains all of the Earth’s air and is divided into troposphere, stratosphere, mesosphere, thermosphere and ionosphere.

The hydrosphere contains all of the solid, liquid and gaseous water on Earth, extending from the depths of the sea to the upper reaches of the troposphere where water is found. Ninety-seven percent of the hydrosphere is found in salty oceans, and the remainder is found as vapor or droplets in the atmosphere and as liquid in ground water, lakes, rivers, glaciers and snowfields.

The biosphere is the collection of all Earth’s life forms, distributed in major life zones known as biomes: tundra, boreal forest, temperate deciduous forest, temperate grassland, desert, savannah, tropical rainforest, chaparral, freshwater, and marine.

Although the four systems have their unique identities, there is substantial interaction between them. Environmental scientists study the effects of events in one sphere on the other spheres. For example, a volcanic eruption in the geosphere may cause profound direct and indirect effects on the hydrosphere, atmosphere and biosphere as follows:

Example 1 (Volcano) On May 18, 1980, Mount Saint Helens, in the state of Washington, erupted. This event altered the surrounding environment, and provided scientists with an opportunity to study the effects of volcanic eruptions on the geosphere, hydrosphere, atmosphere and biosphere. Such studies are vital because volcanic eruptions will continue to occur, and will have increasing impact on humans as people continue to settle lands closer to dormant volcanoes.

The following are but a few of the myriad of interactions resulting from a volcanic eruption.

Volcano >> geosphere >> atmosphere >> hydrosphere >> biosphere Volcanoes (an event in the geosphere) release a large amount of particulate matter into the atmosphere. These particles serve as nuclei for the formation of water droplets (hydrosphere). Rainfall (hydrosphere) often increases following an eruption, stimulating plant growth (biosphere). Particulate matter in the air (atmosphere) falls out, initially smothering plants (biosphere), but ultimately enriching the soil (geosphere) and thereby stimulating plant growth (biosphere).

Volcano >> geosphere >> hydrosphere >> biosphere Volcanoes (events in the geosphere) may release a substantial amount of hot lava (geosphere), which causes mountain glaciers (hydrosphere) to melt. Mudflows (geosphere) and flooding may occur downstream from volcanoes and may inundate streamside communities (biosphere).





Volcano >> geosphere >> atmosphere >> biosphere >> geosphere Volcanoes (events of the geosphere) release a large amount of carbon dioxide (atmosphere), the raw material for sugar production in plants (biosphere). This may increase photosynthetic production and eventually increase the amount of biomass, which, after a very long time, forms coal and oil deposits (geosphere).

Volcano >> complex interactions Volcanoes (geosphere) may emit large quantities of sulfur dioxide (atmosphere). When atmospheric sulfur dioxide combines with water (hydrosphere), sulfuric and sulfurous acid form. Rain (hydrosphere) may bring these acids to the Earth, acidifying soils (geosphere), lakes and rivers (hydrosphere). Acidic water leaches nutrients from the soil (geosphere) into the water table (hydrosphere), making the soil less fertile for plants (biosphere), and the subterranean water supply (hydrosphere) less potable for humans (biosphere). Acid rain falling on lakes and streams reduces the pH of the water (hydrosphere), which may result in a decrease in phytoplankton and zooplankton growth (biosphere). If photosynthesis is reduced, atmospheric concentrations of carbon dioxide can build up and stimulate global warming (atmosphere) which may contribute to increased melting of glaciers (hydrosphere).

Man and Environment

All living beings including man and their environment are mutually reactive, affecting each other in a number of ways. It is generally equated with nature wherein physical components of the planet earth such as earth, air, water, etc. support and affect life in the biosphere.

Environment represents the physical components of the earth, wherein man is an important factor affecting the environment.

Environment comprises interacting systems of physical, biological, and cultural elements, which are interlinked individually as well as collectively in various ways.

Constituents of Environment

Physical elements constitute space, landforms, water-bodies, climate, soils, rocks, and minerals. These elements determine the variable character of human habitat, and also its opportunities and limitations.

Biological elements include plants, animals, micro-organisms, and man.

Cultural elements include economic, social and political conditions which are largely man-made features.

Types of Environment

Since environment is a combination of physical and biological factors, it contains both living or biotic and non-living or abiotic components. On the basis of this basic structure, environment can be divided into physical or abiotic and living or biotic environment.

Physical or Abiotic Environment

Physical environment is made up of the following states - solid, liquid, and gas. These three elements signify lithosphere, hydrosphere, and atmosphere respectively. On the basis of spatial distribution, smaller units are termed as coastal environment, plateau environment, mountain environment, lake environment, river environment, maritime environment, etc.

Living or Biotic Environment





Biotic environment consists of plants (flora) and animals (fauna) including human beings as a significant factor. Thus, biotic environment can be of two types such as floral environment and faunal environment.

Apart from the above, there are social, cultural, and psychological environment.

Social and Cultural Environment

This type of environment includes the varied aspects of socio-cultural interactions along with its outcomes such as beliefs, attitudes, stereotypes etc. The tangible and intangible aspects of environment are included in it.

Psychological Environment

Psychological environment deals with the perception and experiences related to any environmental setting. Some environment may be stimulating and exciting for us, while others may be dull and boring.

Psychological environment is more often used in the organizational context.

Man-Environment Relationship

Man and environment relationship is as old as the evolution of mankind. Since the evolution of man, the physical elements of the planet earth, such as terrain, soil, water, climate, flora and fauna formed man's environment. During that time man was a typically a 'physical man' because of his limited wants, requirements, and total dependence on nature.

With the growth in social and economic activities, advancement in technologies, man expanded his own environment through design and skill to have provisions for improved and better food, shelter, access, and comfort or luxuries. Man's ability to survive in a variety of ecosystem and his unique ability to adapt to a great variety of external conditions make man-environment relationship quite a fascinating area of study.

The environment in which man survives and to which he adapts himself and which he influences include physical, socio-cultural, and biological aspects. Man and environment has never been static and a great many factors are responsible for the shifts in man environment relationship.

Biogeographic provinces of the world

Biogeographic provinces are categories used for comparing and contrasting biogeochemical processes and biodiversity between ocean regions. Provinces provide a framework for reasonable extrapolation of point or transect data to broader areas. However, their use is limited due to the non-automatic, subjective nature of province classification. Furthermore, it is unknown how province boundaries respond to seasonal and climate forcing. These issues make province related hypotheses difficult to test with static provinces. To solve this problem, we use objective classification on global remote sensing data to automatically produce time and space resolved ocean provinces.

Seasonal patterns in province geography reflect well-known ocean processes. Our predictions of province boundaries are verified by in-situ ship track data and province distributions in the equatorial Pacific correlate well with ENSO indexes. This objective classification system captures spatial and temporal province dynamics and provides objective categories for cross-province biogeochemical hypotheses to be rigorously tested.





Bio-geographic provinces of the world List

1Afrotropical Realm 2Antarctic Realm 3Australasian Realm 4Indomalayan Realm 5Nearctic Realm 6Neotropical Realm 7Oceanian Realm 8Palearctic Realm 9Region coding 10See also 11References 12Bibliography Bio-geographic Zones and Bio-geographic Provinces of India

Bio-geographic Zones of India	Bio-geographic Provinces of India
Trans Himalaya	1A: Himalaya- Ladakh Mountains 1B: Himalaya-Tibetan Plateau 1C: Trans-Himalaya Sikkim
The Himalaya	2A: Himalaya- North West Himalaya 2B: Himalaya- West Himalaya 2C: Himalaya- Central
	Himalaya 2D: Himalaya- East Himalaya
The Indian Desert	3A: Desert-Thar 3B: Desert-Katchchh
The Western Ghats	4A: Western Ghats-Malabar Plains 5B: Western Ghats- Western Ghats Mountains
The Deccan Peninsula	6A: Deccan Peninsular-Central Highlands 6B: Deccan Peninsular-Chotta Nagpur 6C: Deccan Peninsular-Eastern Highland 6D: Deccan Peninsular-Central Plateau 6E: Deccan Peninsular-Deccan South
The Gangetic Plains	7A: Gangetic Plain- Upper Gangetic Plains 7B: Gangetic Plain- Lower
	Gangetic Plains
The Coasts	8A: Coasts-West Coast 8B: Coasts- East Coast 8C: Coasts-Lakshadweep
North-East India	9A: North-East- East-Brahmaputra Valley 9B: North-East-North East Hills
Islands	10A: Islands-Andaman 10B: Islands-Nicobar

Biogeography classification of India was done by Rodgers and Panwar in 1988. The classification was done using various factors such as altitude, moisture, topography, rainfall etc.

Agro-Climatic Zone

Green Revolution provided the much needed food security to the vast population of the Indian Nation but in spite of being one of the top producers of almost all agricultural commodities, the productivity is still very low compared to many other countries in the world. In this article, we have explained the term and the importance of the Agro-Climatic Zone which is very useful for the competitive examinations like UPSC- prelims, SSC, State Services, NDA, CDS, and Railways etc.

Food and Agriculture Organization (FAO) defined an agro-climatic zone (ACZ) as a land unit represented accurately or precisely in terms of major climate and growing period, which is climatically suitable for certain range of crops and cultivars. In other words, it is an extension of the climate classification keeping in view the suitability to agriculture.



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Multiple Choice Question

1- The following is (are) abiotic components.

- a) Plants
- b) Animals
- c) Land
- d) All of the above Answer: c

2- The following is the solid crust or the hard top layer of the earth.

- a) Lithosphere
- b) Hydrosphere
- c) Atmosphere
- d) Biosphere Answer: a

3- An irregular surface with various landforms such as mountains, plateaus, plains, valleys, etc is

- a) Hydrosphere
- b) Biosphere
- c) Lithosphere
- d) Atmosphere Answer: c

4- The force of the earth holds the atmosphere around it

- a) Magnetic
- b) Gravitational
- c) Centrifugal
- d) All of the above Answer: b

5- There could be an ecosystem of

- a) Large rain forest
- b) Desert
- c) Ocean
- d) All of the above Answer: d

6- The following is not a natural ecosystem

- a) Pond
- b) Desert
- c) Aquarium
- d) Ocean Answer: c

7- The thickness of crust on the ocean floors is about

- a) 5km
- b) 15km
- c) 25km
- d) 35km Answer: a

8- The continental mass is known as

- a) sial
- b) sima
- c) nife
- d) sini Answer: a

9- The oceanic crust is called

- a) sial
- b) sima
- c) nife
- d) sini Answer: b

10- The innermost layer of the earth is made up of

- a) Silicon and Alumina
- b) Silicon and Magnesium
- c) Silicon and Nickel
- d) Nickel and Iron Answer: d

11- The rock formed when molten magma cools

- a) Sedimentary rock
- b) Igneous rock
- c) Metamorphic rock
- d) All of the above Answer: b

12- An example of intrusive igneous rock is

- a) Granite
- b) Basalt
- c) Marble
- d) All of the above Answer: a

13- Igneous and Sedimentary rocks can change into metamorphic rocks under great and

- a) Heat, pressure





- b) Heat, temperature
- c) Volume, heat
- d) Volume, temperature Answer: a

14- Under great heat and pressure, limestone changes to

- a) Granite
- b) Slate
- c) Marble
- d) Basalt Answer: c

15- The process of transformation of the rock from one to another is known as

- a) Rock transformation
- b) Rock formation
- c) Rock cycle
- d) Rock recycle Answer: c

16. At what concentration (in ppm), is nitrogen present in the atmosphere? a) 780,840

- b) 390,420
- c) 78,084
- d) 900,000 Answer: a

Explanation: Nitrogen constitutes 78% of the atmosphere. So 78% of one million = 780,840 ppm – is the concentration of nitrogen gas in the atmosphere.

17. In the lower layers of atmosphere, what range of wavelengths of light is predominant?

- a) Less than 100 nm
- b) Greater than 300 nm
- c) Between 100-300 nm
- d) All wavelengths are equally present Answer: b

Explanation: In the lower layers of atmosphere, light of wavelengths greater than 300nm are present and it is because of this reason, there is generally no ozone formation at the ground level.

18. What does the ratio of the mass of water vapour to mass of air indicate?

- a) Absolute humidity
- b) Specific humidity

c) Relative humidity

d) Approximate humidity Answer: b

Explanation: Specific humidity is the mass of water vapour per unit mass of air mixture.

19. What is the region of mild and irregular wind in the equatorial region known as?

- a) Trade winds
- b) Westerlies
- c) Doldrums
- d) Easterlies Answer: c

Explanation: Doldrums are the irregular winds and their exact location is hard to analyse. Ships in the region of doldrums might restrict its movement due to a lack of proper wind.

20. “Roaring forties” is the term used to describe which of the following winds?

- a) East-to-west air winds in the southern hemisphere
- b) West-to east air winds in the northern hemisphere
- c) East-to-west air winds in the northern hemisphere
- d) West-to-east air winds in the southern hemisphere Answer: d

Explanation: Roaring forties found in the southern hemisphere are strong westerly winds caused by air displaced from the equator to the South Pole and aid yachtsmen in on competitions and voyages.

21. Which of the following statements is true?

- a) Troposphere is equally thick across different parts of the world
- b) Troposphere contains the ozone layer
- c) Troposphere is thinner at the equator than at the poles
- d) Troposphere is thicker at the equator than at the poles Answer: d

Explanation: Troposphere is nearly 16-17km thick at the equator and thins down to approximately 8km at the poles.





22. The temperature decreases with altitude in the stratosphere layer.

- a) True
- b) False Answer: b

Explanation: Temperature slightly increases with altitude in the stratosphere due to absorption of UV radiations from the sun, by the ozone layer present in the stratosphere.

23. Which of the following indicates the correct order of the principal layers of the earth's atmosphere from top to bottom?

- a) Troposphere – Stratosphere – Mesosphere – Thermosphere – Exosphere
- b) Thermosphere – Stratosphere – Troposphere – Mesosphere – Exosphere
- c) Exosphere – Thermosphere – Mesosphere – Stratosphere – Troposphere
- d) Exosphere – Mesosphere – Thermosphere – Stratosphere – Troposphere Answer: c

Explanation: Exosphere is the outermost layer of the atmosphere followed by mesosphere, thermosphere, stratosphere and troposphere.

24. Which layer of the atmosphere is responsible for aurora formation?

- a) Ozone layer
- b) Stratosphere
- c) Exosphere
- d) Ionosphere Answer: d

Explanation: Ionosphere is a secondary layer of the atmosphere which extends through mesosphere, thermosphere and exosphere during day time and is responsible for aurora – natural light display in the sky in high altitude region.

25. Which of the following mentioned layers is NOT a homosphere?

- a) Exosphere
- b) Troposphere
- c) Ionosphere
- d) Mesosphere Answer: a

Explanation: Homospheric layers of atmosphere include layers where chemical composition

is independent of molecular weight of gases due to mixing by turbulence. Hence the lower layers such as troposphere, ionosphere and mesosphere are homospheres.

26. Turbopause is highest layer of the homosphere.

- a) True
- b) False Answer: a

Explanation: Turbopause marks the height at which homogenous layer, the homosphere ends. Below the turbopause, turbulent mixing of air dominates.

27. The planetary boundary layer belongs to which of the following atmospheric layers?

- a) Exosphere
- b) Ionosphere
- c) Stratosphere
- d) None of the mentioned Answer: d

Explanation: The planetary boundary layer is the lowermost level of the atmosphere and it belongs to the troposphere.

28. What is the atmospheric pressure at sea level?

- a) 101325 Pa
- b) 14.696 psi
- c) 760 Torr
- d) All of the mentioned Answer: d

Explanation: As per International Standard Atmosphere, at sea level atmospheric pressure is equal to 101325 Pa which is equal to 14.696 psi and 760 Torr.

29. By international convention, which line marks the outermost boundary of the Earth's atmosphere?

- a) Space line
- b) Boundary line
- c) Karman line
- d) Astronaut line Answer: c

Explanation: The Karman line lies at an altitude of 100 km, between the atmospheric boundary of the Earth and outer space.





30. The hydrosphere is the mass of water found
a. on the earth
b. found under the earth
c. above the surface of a planet
d. all of the above Answer: D

31. Fresh water accounts for ___ of the water on earth.
(A) 2.5%
(B) 5%
(C) 7.5%
(D) 10% Answer: A

32. Out of the fresh water ___ is in the form of ice and permanent snow cover in the Arctic.
(A) 58.9%
(B) 68.9%
(C) 78.9%
(D) 88.9% Answer: B

33. How much portion of earth's surface is covered by ocean?
(A) 61%
(B) 66%
(C) 71%
(D) 76% Answer: C

34. The average salinity of Earth's oceans is about ___ of salt per kilogram of sea water.
a. 35 grams
b. 55 grams
c. 75 grams
d. 95 grams Answer: A

35. The water cycle refers to the transfer of water from
a. one state to another
b. one reservoir to another
c. both (a) and (b)
d. none of the other Answer: C

36. Following is (are) reservoir(s)
a. atmospheric moisture
b. groundwater
c. oceans
d. all of the above Answer: D

37. Sublimation refers to evaporation from
a. snow
b. oceans
c. rivers
d. ponds Answer: A

38. Most evaporation comes from
a. rivers
b. oceans
c. snow
d. none of the above Answer: B

39. ___ refers to the expiration of water through the minute pores or stomata of trees.
a. Evaporation
b. Transpiration
c. Sublimation
d. all of the above Answer: B

40. ___ is the term used by hydrologists in reference to the process(es)
a. transpiration
b. sublimation
c. evaporation
d. together transpiration, sublimation and evaporation Answer: D

41. The total runoff of the Earth's rivers is
a. 32,700 km³/year
b. 38,500 km³/year
c. 42,700 km³/year
d. 48,500 km³/year Answer: C

42. Earth is also known as
a. Red planet
b. Blue planet
c. Brown planet
d. None of the above Answer: B

43. Of the fresh water, ___ is in the form of fresh groundwater.
(A) 25.4%
(B) 28.7%
(C) 30.8%
(D) 32.5% Answer: C

44. The transfer of heat between two bodies in direct contact is called





- a) radiation
 - b) convection
 - c) conduction
 - d) none of the mentioned Answer: c
- Explanation: This is the definition of conduction.

45. Heat flow into a system is taken to be ____, and heat flow out of the system is taken as

- a) positive, positive
- b) negative, negative
- c) negative, positive
- d) positive, negative Answer: d

Explanation: The direction of heat transfer is taken from the high temperature system to the low temperature system.

46. In the equation, $dQ = TdX$

- a) dQ is an inexact differential
- b) dX is an exact differential
- c) X is an extensive property
- d) all of the mentioned Answer: d

Explanation: This is because heat transfer is a path function.

47. The transfer of heat between a wall and a fluid system in motion is called

- a) radiation
- b) convection
- c) conduction
- d) none of the mentioned Answer: b

Explanation: This is the definition of convection.

48. For solids and liquids, specific heat

- a) depends on the process
- b) is independent of the process
- c) may or may not depend on the process
- d) none of the mentioned Answer: b

Explanation: It is the property of specific heat.

49. The specific heat of the substance is defined as the amount of heat required to raise a unit mass of the substance through a unit rise in temperature.

- a) true
 - b) false Answer: a
- Explanation: $c = Q / (m \Delta t)$.

50. Heat and work are

- a) path functions
- b) inexact differentials
- c) depend upon the path followed
- d) all of the mentioned Answer: d

Explanation: It is an important point to remember regarding heat and work transfer.

51. Latent heat is taken at

- a) constant temperature
- b) constant pressure
- c) both of the mentioned
- d) none of the mentioned Answer: c

Explanation: The latent heat is heat transfer required to cause a phase change in a unit mass of substance at a constant pressure and temperature.

52. Which of the following is true?

- a) latent heat of fusion is not much affected by pressure
- b) latent heat of vaporization is highly sensitive to pressure
- c) both of the mentioned
- d) none of the mentioned Answer: c

Explanation: It is a general fact about latent heat.

53. Heat transfer and work transfer are

- a) boundary phenomena
- b) energy interactions
- c) energy in the transit
- d) all of the mentioned Answer: d

Explanation: It is an important point to remember regarding heat and work transfer.

54. Energy has different forms which include

- a) heat
- b) work
- c) all of the mentioned





d) none of the mentioned Answer: c
Explanation: Basic fact about energy.

55. Work input is directly proportional to heat and the constant of proportionality is called

- a) joule's equivalent
- b) mechanical equivalent of heat
- c) all of the mentioned

d) none of the mentioned Answer: c
Explanation: True for a closed system undergoing a cycle.

56. The value of constant of proportionality, J, has the value

- a) 1
- b) 0
- c) -1
- d) Infinity Answer: a

Explanation: In the S.I. system, both heat and work are measured in the derived unit of energy, the Joule.

57. It was Joule who first established that heat is a form of energy, and thus laid the foundation of the first law of thermodynamics.

- a) true
- b) false Answer: a

Explanation: Prior to Joule, heat was considered to be an invisible fluid flowing from a body of higher calorific to a body of lower calorific.

58. Which of the following represents the energy in storage?

- a) heat
- b) work
- c) internal energy
- d) none of the mentioned Answer: c

Explanation: Energy in storage is internal energy or the energy of the system.

59. By first law of thermodynamics,

- a) $Q = \Delta E - W$

b) $Q = \Delta E + W$

c) $Q = -\Delta E - W$

d) $Q = -\Delta E + W$ Answer: b

Explanation: $Q - W$ is the net energy stored in system and is called internal energy of system.

60. The expression $(\sum W)_{\text{cycle}} = (\sum Q)_{\text{cycle}}$ applies only to systems undergoing cycles.

- a) true
- b) false Answer: a

Explanation: The above expression holds for a closed cycle.

61. Which of the following is the first law for a closed system undergoing a cycle?

- a) $\oint dW = \oint dQ$
- b) $\int J dW = \int dQ$
- c) $\oint dW = J \oint dQ$
- d) none of the mentioned Answer: c

Explanation: This is the expression for first law of thermodynamics where \oint denotes the cyclic integral for the closed path.

62. Which of the following can be considered as the definition of energy?

- a) $Q = \Delta E + W$
- b) $Q - W = \Delta E$
- c) first law of thermodynamics
- d) all of the mentioned Answer: d

Explanation: The first law is a particular formulation of the principle of the conservation of energy.

63. The first law of thermodynamics gives only the change on energy ΔE for the process.

- a) true
- b) false Answer: a

Explanation: An absolute value of energy E , is not given by the first law.

64. Energy is a

- a) point function
- b) property of the system
- c) extensive property





d) all of the mentioned Answer: d
Explanation: Energy has a definite value for every state of the system.

65. The specific energy, $e=E/m$ is an extensive property.

- a) true
- b) false Answer: b

Explanation: The specific energy is an intensive property.

66. $(m \cdot V^2)/2$ gives the

- a) macroscopic kinetic energy
- b) microscopic kinetic energy
- c) macroscopic potential energy
- d) microscopic potential energy Answer: a

Explanation: The formula gives the macroscopic kinetic energy of the fluid element by virtue of its motion.

67. $(m \cdot g \cdot z)$ gives the

- a) macroscopic kinetic energy
- b) microscopic kinetic energy
- c) macroscopic potential energy
- d) microscopic potential energy Answer: c

Explanation: The above formula gives the macroscopic potential energy of the fluid element by virtue of its position.

68. Which of the following types of energy can be present in molecules?

- a) translational and rotational kinetic energy
- b) electronic energy and vibrational energy
- c) chemical energy and nuclear energy
- d) all of the mentioned Answer: d

Explanation: The molecules may be subjected to rotation as well as vibration due to a collision.

69. The total internal energy of the system is given by

- a) $U=N/\epsilon$
- b) $U=N\epsilon$
- c) $U=\epsilon/N$

d) none of the mentioned Answer: b
Explanation: $U=N\epsilon$ where N is the total number of molecules in the system and ϵ represents the energy of one molecule.

70. In an ideal gas there are no intermolecular forces of attraction and repulsion, and the internal energy is a function of temperature only.

- a) true
- b) false Answer: a

Explanation: For an ideal gas U depends only on T .

71. Which of the following is true in regard to the energy of an isolated system?

- a) $dQ \neq 0$
- b) $dW \neq 0$
- c) $E = \text{constant}$
- d) all of the mentioned Answer: c

Explanation: For an isolated system, $dQ = dW = 0$ and hence, $dE = 0$ by first law.

72. A perpetual motion machine of first kind

- a) is a fictitious machine
- b) can supply mechanical work without dissipating energy
- c) violates first law
- d) all of the mentioned Answer: d

Explanation: There cannot be any machine which would continuously supply mechanical energy without other form of energy being dissipated.

73. The limitation of the first law is

- a) does not indicate the possibility of a spontaneous process proceeding in a definite direction
- b) it assigns a quality to different forms of energy
- c) indicates the direction of any spontaneous process
- d) none of the mentioned Answer: a

Explanation: This is the main limitation of first law and the second law overcomes it.





74. Convection does not occur in

- a) Solid
- b) Liquid
- c) Gas
- d) Molten Solid Answer: a

Explanation: Convection cannot take place in most solids because neither bulk current flows nor significant diffusion of matter can take place.

Diffusion of heat takes place in rigid solids, but that is called heat conduction. Convection, however, can take place in soft solids or mixtures where solid particles can move past each other.

75. The unit of mass transfer coefficient is

- a) $m^{-1}s$
- b) ms^{-1}
- c) $m^{-1}s^2$
- d) m^2s^{-1} Answer: b

Explanation: $(mol/s)/(m^2 \cdot mol/m^3) = m/s$

Note, the units will vary based upon which units the driving force is expressed in. The driving force shown here as ' ΔcA ' is expressed in units of moles per unit of volume, but in some cases the driving force is represented by other measures of concentration with different units.

For example, the driving force may be partial pressures when dealing with mass transfer in a gas phase and thus use units of pressure.

76. Rate of mass transfer is inversely proportional to the rate of reaction at solid surface?

- a) True
- b) False Answer: b

Explanation: Estimation of the interfacial concentration C_{Ai} is more difficult; measuring compositions at phase boundaries is not easy experimentally. To overcome this problem, we must consider the processes in the system which are linked to mass transfer of A. Transport of A is linked to reaction at the surface of the solid, so that the value of C_{Ai} will

depend on the rate of consumption of A at the interface. In practical terms, we can therefore calculate the rate of mass transfer of A only if we have information about the rate of reaction at the solid surface. Simultaneous reaction and mass transfer occurs in many bioprocesses.

77. Psychrometry deals with between which type of phases?

- a) Gas-liquid
- b) Gas-solid
- c) Gas-Vapour
- d) Vapour-Solid Answer: c

Explanation: Psychrometry is concerned with the physical and thermodynamic properties of gas-vapor mixtures. Although the principles of psychrometry apply to any physical system consisting of gas-vapor mixtures, the most common system of interest is the mixture of water vapor and air, because of its application in heating, ventilating, and air-conditioning and meteorology. In human terms, our thermal comfort is in large part a consequence of not just the temperature of the surrounding air, but (because we cool ourselves via perspiration) the extent to which that air is saturated with water vapor.

78. Which type of columns are used for liquid dispersion in a continuous gas phase?

- a) Packed
- b) Bubble cap
- c) Sieve - plate
- d) Fluidized bed Answer: a

Explanation: Packed Beds. Although packed bed columns are used most often for absorption, they are also used for the distillation of vapor-liquid mixtures. The packing provides a large surface area for vapor-liquid contact, which increases the column's effectiveness.

79. Heat transfer by molecular collision in_

- a) Conduction
- b) Convection
- c) Scattering





d) Radiation Answer: b

Explanation: Flow of heat through currents within a fluid (liquid or gas). Convection is the displacement of volumes of a substance in a liquid or gaseous phase. When a mass of a fluid is heated up, for example when it is in contact with a warmer surface, its molecules are carried away and scattered causing that the mass of that fluid becomes less dense. For this reason, the warmed mass will be displaced vertically and/or horizontally, while the colder and denser mass of fluid goes down (the low-kinetic-energy molecules displace the molecules in high-kinetic-energy states). Through this process, the molecules of the hot fluid transfer heat continuously toward the volumes of the colder fluid.

80. Convection is faster than conduction?

a) True

b) False Answer: a

Explanation: Forced air heating and air conditioning are examples of heating (or cooling) by convection. This is an effective way of bringing a hot (or cold) fluid to a different area. Convection transfers heat over a distance faster than conduction.

81. Which is the fastest mode of transfer of heat?

a) Conduction

b) Convection

c) Scattering

d) Radiation Answer: d

Explanation: Radiation is the fastest mode of transfer of heat, because radiation travels at the speed of light, which is very quick. The slowest mode of transfer of heat is conduction because it takes place from particle to particle. The fastest is radiation at the speed of light 3,00,000 km in one second.

82. Heat transfer takes place as per

a) Zeroth law of thermodynamics

b) First law of thermodynamics

c) Second law of thermodynamics

d) Kirchoff's law Answer: c

Explanation: Second Law of Thermodynamics states that It is not possible for heat to flow from a colder body to a warmer body without any work having been done to accomplish this flow. Energy will not flow spontaneously from a low temperature object to a higher temperature object.

83. Which of the following does the concept of material balance based upon?

a) Conservation of mass

b) Conservation of energy

c) Conservation of momentum

d) Conservation of Volume Answer: a

Explanation: Material is simply conservation of mass.

84. The equation of material balance, (Final condition + Sum of outputs) is equal to which of the following?

a) Initial condition – Sum of inputs

b) Initial condition + Sum of inputs

c) Sum of inputs – Initial condition

d) None of the mentioned Answer: b

Explanation: Equation of material balance is Final condition – Initial condition = Sum of inputs – Sum of outputs, => Final condition + Sum of outputs = Initial condition + Sum of inputs.

85. A container has 10 grams of water 5 grams of water is added and 2 grams of water is taken out, what is the final amount of water?

a) 7 grams

b) 10 grams

c) 13 grams

d) 15 grams Answer: c

Explanation: Final condition = Initial condition + sum of inputs – sum of outputs = 10 + 5 – 2 = 13 grams.

86. 10 moles of O₂ is added to 10 moles of H₂, how many moles of H₂O will it produce?



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planning? **A:** Analyzing land suitability, managing zoning, monitoring changes.

87. **Q:** What is environmental awareness? **A:** Consciousness and understanding of environmental issues.

88. **Q:** What is anthropocentrism in environmental ethics? **A:** Human-centered view of the world.

89. **Q:** What is biocentrism? **A:** Life-centered view, valuing all life forms.

90. **Q:** What is ecocentrism? **A:** Ecosystem-centered view, valuing ecosystems and the Earth as a whole.

91. **Q:** What term refers to the maximum population size that an environment can sustain indefinitely? **A:** Carrying capacity.

92. **Q:** What is the primary source of energy for most ecosystems? **A:** Solar energy.

93. **Q:** What are the components of a GIS system? **A:** Hardware, software, data, people, methods.

94. **Q:** What is the purpose of a map projection in GIS? **A:** To represent the curved Earth surface on a flat map.

95. **Q:** What is spatial data in GIS? **A:** Data that has a geographic location.

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96. **Q:** What is attribute data in GIS? **A:** Non-spatial information associated with spatial features.
97. **Q:** What is the role of vegetation indices (e.g., NDVI) in remote sensing? **A:** To quantify vegetation greenness and health.
98. **Q:** What is the primary function of the ozone layer? **A:** Absorbs harmful ultraviolet (UV) radiation.
99. **Q:** What is the concept of "material flow analysis" related to? **A:** Material balance, tracking substance movement through systems.
100. **Q:** What is a major challenge in implementing sustainable development? **A:** Balancing economic, social, and environmental goals.

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- a) 5
- b) 10
- c) 15

d) 20 Answer: b

Explanation: Balanced equation is $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$, \Rightarrow Moles of H_2O = Moles of H_2 = 10.

87. A combustion reaction has reactants 1 mole of C_xH_y and 2 moles of O_2 and products 1 mole of CO_2 and 2 moles of H_2O , what is $x + y$?

- a) 1
- b) 3
- c) 4

d) 5 Answer: d

Explanation: Moles of C, H and O in reactants = Moles of C, H and O in products, \Rightarrow C: $1 \cdot x = 1 \cdot 1 \Rightarrow x = 1$, H: $1 \cdot y = 2 \cdot 2 \Rightarrow x + y = 5$.

88. In a random reaction 2 moles of CH_4 and 1 mole of C_2H_4 are reacted, and 1 mole of C_3H_8 and 1 mole of C_xH_y are produced, what is $x \cdot y$?

- a) 2
- b) 4
- c) 8

d) 12 Answer: b

Explanation: Material balance for C: $2 \cdot 1 + 1 \cdot 2 = 1 \cdot 3 + 1 \cdot x$, $\Rightarrow x = 1$, for H: $2 \cdot 4 + 1 \cdot 4 = 1 \cdot 8 + 1 \cdot y$, $\Rightarrow y = 4$, $\Rightarrow x \cdot y = 4$.

89. A reaction has reactants 2 moles of NaOH and 1 mole of H_2SO_4 , and products Na_2SO_4 and H_2O , what are the total moles of products?

- a) 1
- b) 2
- c) 3

d) 4 Answer: c

Explanation: Material Balance for Na: $2 \cdot 1 = n_1 \cdot 2 \Rightarrow n_1 = 1$, for H: $2 \cdot 1 + 1 \cdot 2 = n_2 \cdot 2 \Rightarrow n_2 = 2$, \Rightarrow total moles of products = $1 + 2 = 3$.

90. A reaction is $\text{A} + 2\text{B} \rightarrow 3\text{C}$, if 2 moles of A and 4 moles of B entered the system, what are

the number of moles of C formed?

- a) 2
- b) 4
- c) 6

d) 8 Answer: c

Explanation: Moles of C = $3 \cdot 2 = 6$.

91. 10 moles of A were present in a system initially, and 10 moles are added to it, it follows the reaction $4\text{A} \rightarrow \text{B}$, what are the number of moles of B produced?

- a) 5
- b) 10
- c) 15

d) 20 View Answer: a

Explanation: Moles of B = $(10 + 10)/4 = 5$.

92. 10 moles of A were present in a system initially, and 10 moles of C are added to it, it follows the reaction $2\text{A} + \text{C} \rightarrow 5\text{B}$, what is the number of moles of B produced?

- a) 5
- b) 10
- c) 25

d) 50 Answer: c

Explanation: Mole of B = $5 \cdot 5 = 25$.

93. There were 10 moles of a substance present initially in a system, 5 moles were added to it and a reaction occurred so that its moles are reduced by 20%, what are the final moles of a substance in the system?

- a) 10
- b) 12
- c) 15

d) 18 Answer: b

Explanation: Final moles of substance = $(10 + 5) \cdot 80/100 = 12$.

94. There were 15 moles of a substance present initially in a system, 25 moles were added to it and a reaction occurred so that its moles are reduced by 50%, what are the final moles of a substance in the system?

- a) 10





b) 15

c) 20

d) 40 Answer: c

Explanation: Final moles of substance = $(15 + 25) \times 50 / 100 = 20$.

95. 10 moles of A were present in a system initially, and 12 moles of C are added to it, it undergoes the reaction $2A + 3C \rightarrow 2B$, what are number of moles of B produced?

a) 4

b) 5

c) 8

d) 12 Answer: c

Explanation: Moles of B = $2 \times 4 = 8$.

96. 10 moles of A were present in a system initially, and 8 moles of C are added to it, it undergoes the reaction $5A + 3C \rightarrow 4B$, what are number of moles of B produced?

a) 4

b) 6

c) 8

d) 10 Answer: c

Explanation: Moles of B = $4 \times 2 = 8$.

97. 8 moles of A were present in a system initially, and 24 moles of B are added to it, it undergoes the reaction $2A + 3B \rightarrow 4C + 5D$, what are the number of moles of D produced?

a) 10

b) 20

c) 30

d) 40 Answer: c

Explanation: Moles of D = $5 \times 4 = 20$.

98. What does the word 'meteorology' define?

a) Study of meteors and asteroids

b) Study of measurements and instruments

c) Study of chemical properties of metals

d) Study of the weather and atmospheric changes Answer: d

Explanation: Meteorological information is necessary to predict and plan the control of air

pollution.

99. What is a "tetroon" in the field of meteorology?

a) A tool used to study wind patterns

b) A tool used to study pressure variations

c) A tool used to study temperature deviations

d) A tool used to study humidity Answer: a

Explanation: Tetroon – Tetrahedral Balloon drifts horizontally along with the wind and is tracked by radar. It is used to analyse local wind patterns.

100. What is high pressure area with sinking air also known as?

a) Cyclone

b) Anti-cyclone

c) Eddy zone

d) Richardson zone Answer: b

Explanation: Anticyclones are high pressure regions with low ventilation where air is sinking, and is warmed by compression.

101. What does the term "turbidity" indicate in atmospheric quality?

a) Indicates density of clouds

b) Reduction of light due to dust particles

c) Indicates the humidity

d) Turbulence of winds Answer: b

Explanation: Turbidity is the term used to describe reduction in light/visibility due to smoke and other dust particles. Due to air pollution, about 15-20% reduction in sunshine is observed in cities.

102. Which of the following gases vary significantly over time and place at the atmospheric boundary level?

a) Carbon dioxide

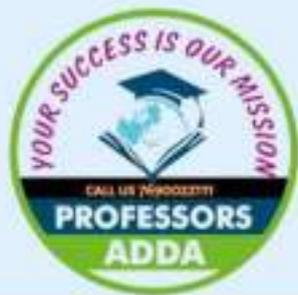
b) Ozone

c) Water vapour

d) Oxygen Answer: c

Explanation: Water vapour varies based on time and place at the atmospheric boundary level due to the continuous action of evapora-





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Q1. Assertion (A): The ecological pyramid of biomass is generally inverted for a pond ecosystem.

Reason (R): The biomass of phytoplankton, the producers, at any given time is much lower than the biomass of zooplankton and fish.

- (1) Both (A) and (R) are true and (R) is the correct explanation of (A).
- (2) Both (A) and (R) are true but (R) is not the correct explanation of (A).
- (3) (A) is true but (R) is false.
- (4) (A) is false but (R) is true.

Ans: (1)

Q2. Match List-I (Environmental Acts) with List-II (Year of Enactment).

List-I (Environmental Acts)	List-II (Year of Enactment)
(a) The Water (Prevention and Control of Pollution) Act	(i) 1986
(b) The Air (Prevention and Control of Pollution) Act	(ii) 1972

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(c) The Environment (Protection) Act	(iii) 1974
(d) The Wild Life (Protection) Act	(iv) 1981

Choose the correct answer from the options given below:

- (1) (a)-(iii), (b)-(iv), (c)-(i), (d)-(ii)
- (2) (a)-(iv), (b)-(iii), (c)-(ii), (d)-(i)
- (3) (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii)
- (4) (a)-(iii), (b)-(iv), (c)-(ii), (d)-(i)

Ans: (1)

Q3. Given below are two statements:

Statement I: In a power plant, the electrostatic precipitator (ESP) is most efficient in collecting very fine particles (less than $0.1 \mu\text{m}$).

Statement II: The collection efficiency of a cyclone separator is highest for larger particles and decreases with decreasing particle size.

In light of the above statements, choose the most appropriate answer from the options given below:

- (1) Both Statement I and Statement II are correct.
- (2) Both Statement I and Statement II are incorrect.
- (3) Statement I is correct but Statement II is incorrect.
- (4) Statement I is incorrect but Statement II is correct.

Ans: (4)

Q4. Arrange the following greenhouse gases in decreasing order of their Global Warming Potential (GWP) over a 100-year time horizon.

- (a) Methane (CH₄)
- (b) Nitrous Oxide (N₂O)
- (c) Sulphur hexafluoride (SF₆)
- (d) Carbon dioxide (CO₂)

Choose the correct answer from the options given below:

- (1) (c) > (b) > (a) > (d)
- (2) (c) > (a) > (b) > (d)
- (3) (b) > (c) > (a) > (d)
- (4) (a) > (b) > (c) > (d)

Ans: (1)

Q5. Which of the following are considered secondary air pollutants?

- (a) Ozone (O₃)
- (b) Peroxyacetyl Nitrate (PAN)
- (c) Sulphur Dioxide (SO₂)
- (d) Carbon Monoxide (CO)
- (e) Aldehydes

Choose the correct answer from the options given below:

- (1) (a), (b) and (c) only

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- (2) (a), (b) and (e) only
- (3) (b), (c) and (d) only
- (4) (c), (d) and (e) only

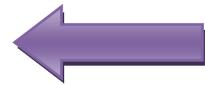
Ans: (2)

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Q6. The acceptable limit of Fluoride in drinking water as per IS 10500:2012 is:

- (1) 0.5 mg/L
- (2) 1.0 mg/L
- (3) 1.5 mg/L
- (4) 2.0 mg/L

Ans: (2) (Permissible limit is 1.5 mg/L, but acceptable is 1.0 mg/L)

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Q7. Assertion (A): Persistent Organic Pollutants (POPs) are subject to long-range environmental transport.

Reason (R): POPs are semi-volatile, enabling them to move between gaseous, dissolved, and sorbed phases, facilitating their transport through air and water currents.

- (1) Both (A) and (R) are true and (R) is the correct explanation of (A).
- (2) Both (A) and (R) are true but (R) is not the correct explanation of (A).
- (3) (A) is true but (R) is false.
- (4) (A) is false but (R) is true.

Ans: (1)

Q8. A noise source increases its sound pressure level by 20 dB. The corresponding increase in pressure amplitude is by a factor of:

- (1) 2
- (2) 10
- (3) 20
- (4) 100

Ans: (2)

Q9. Match List-I (Waste Management Technique) with List-II (Primary Principle/Product).

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List-I	List-II
(a) Incineration	(i) Biological decomposition in the absence of oxygen
(b) Composting	(ii) Thermal destruction with energy recovery
(c) Anaerobic Digestion	(iii) Land disposal in engineered pits
(d) Secure Landfill	(iv) Aerobic biological decomposition to produce humus-like material

Choose the correct answer from the options given below:

- (1) (a)-(ii), (b)-(iv), (c)-(i), (d)-(iii)
- (2) (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii)
- (3) (a)-(iii), (b)-(iv), (c)-(i), (d)-(ii)
- (4) (a)-(i), (b)-(ii), (c)-(iii), (d)-(iv)

Ans: (1)

Q10. The 'precautionary principle' and the 'polluter pays principle' were declared as essential features of Sustainable Development in which landmark legal case in India?

- (1) M.C. Mehta vs. Union of India (Oleum Gas Leak Case)
- (2) Vellore Citizens Welfare Forum vs. Union of India

(3) Indian Council for Enviro-Legal Action vs. Union of India (Bichhri Village Case)

(4) T.N. Godavarman Thirumulpad vs. Union of India

Ans: (2)

Q11. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): For a stable atmospheric condition, the Dry Adiabatic Lapse Rate (DALR) is greater than the Environmental Lapse Rate (ELR).

Reason (R): In a stable atmosphere, a lifted parcel of air becomes cooler and denser than the surrounding air and tends to sink back to its original position.

(1) Both (A) and (R) are true and (R) is the correct explanation of (A).

(2) Both (A) and (R) are true but (R) is not the correct explanation of (A).

(3) (A) is true but (R) is false.

(4) (A) is false but (R) is true.

Ans: (1)

Q12. Arrange the following international conventions and protocols in the chronological order of their adoption.

(a) Paris Agreement

(b) Kyoto Protocol

- (c) Montreal Protocol
- (d) Rio Summit (UNCED)

Choose the correct answer from the options given below:

- (1) (c), (d), (b), (a)
- (2) (d), (c), (b), (a)
- (3) (c), (b), (d), (a)
- (4) (b), (c), (d), (a)

Ans: (1)

Q13. Which of the following statements about r-selected and K-selected species are correct?

- (a) r-selected species have a short lifespan and high mortality rate.
- (b) K-selected species produce a large number of offspring with little parental care.
- (c) Population size of r-selected species is generally close to the carrying capacity.
- (d) K-selected species are typically found in stable or predictable environments.
- (e) Pioneer species in ecological succession are often r-strategists.

Choose the most appropriate answer from the options given below:

- (1) (a), (b) and (c) only
- (2) (b), (c) and (d) only
- (3) (a), (d) and (e) only

(4) (c), (d) and (e) only

Ans: (3)

Q14. A Gaussian plume model for air pollutant dispersion is based on which of the following key assumptions?

(a) The emission rate from the source is continuous and constant.

(b) The pollutant is conservative and does not undergo chemical reactions.

(c) The terrain is flat, open country.

(d) The wind speed is variable with height according to a power law profile.

(e) The pollutant concentration distribution crosswind and vertically is a Gaussian distribution.

Choose the most appropriate answer from the options given below:

(1) (a), (b), (d) only

(2) (a), (c), (e) only

(3) (a), (b), (c), (e) only

(4) (b), (d), (e) only

Ans: (3) (Note: While wind shear (d) can be incorporated, the basic model assumes constant wind speed and direction. a, b, c, e are the most fundamental assumptions).

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Q15. The redox potential (Eh) of an aqueous system is a measure of its:

- (1) Acidity or alkalinity
- (2) Electron availability or oxidizing/reducing capacity
- (3) Dissolved salt concentration
- (4) Temperature and pressure conditions

Ans: (2)

Q16. Match List-I (Soil Texture Class) with List-II (Dominant Particle Size).

List-I	List-II
(a) Sand	(i) < 0.002 mm
(b) Silt	(ii) 0.05 to 2.0 mm
(c) Clay	(iii) 0.002 to 0.05 mm
(d) Loam	(iv) Mixture of sand, silt, and clay

Choose the correct answer from the options given below:

- (1) (a)-(ii), (b)-(iii), (c)-(i), (d)-(iv)
- (2) (a)-(i), (b)-(ii), (c)-(iii), (d)-(iv)
- (3) (a)-(iv), (b)-(i), (c)-(ii), (d)-(iii)
- (4) (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii)

Ans: (1)

Q17. Assertion (A): Biodiversity hotspots are regions

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with very high levels of species richness and a high degree of endemism.

Reason (R): These hotspots are also areas that have lost at least 70% of their original natural vegetation, making them priorities for conservation.

(1) Both (A) and (R) are true and (R) is the correct explanation of (A).

(2) Both (A) and (R) are true but (R) is not the correct explanation of (A).

(3) (A) is true but (R) is false.

(4) (A) is false but (R) is true.

Ans: (2) (Both statements are the defining criteria for a hotspot, not one explaining the other).

Q18. The "Tragedy of the Commons" describes a situation where:

(1) Individual users, acting independently according to their own self-interest, behave contrary to the common good of all users by depleting or spoiling a shared resource through their collective action.

(2) A centrally planned economy fails to allocate resources efficiently.

(3) Private ownership of resources leads to their over-exploitation.

(4) A natural disaster destroys a community's shared resources.

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Ans: (1)

Q19. Given below are two statements:

Statement I: Chi-square test is a parametric statistical test used for comparing observed frequencies with expected frequencies.

Statement II: Student's t-test is used to compare the means of two groups and assumes that the data is normally distributed and has equal variance.

In light of the above statements, choose the most appropriate answer from the options given below:

- (1) Both Statement I and Statement II are correct.
- (2) Both Statement I and Statement II are incorrect.
- (3) Statement I is correct but Statement II is incorrect.
- (4) Statement I is incorrect but Statement II is correct.

Ans: (4) (Chi-square is a non-parametric test).

Q20. What are the primary objectives of an Environmental Impact Assessment (EIA)?

- (a) To predict environmental impacts at an early stage in project planning and design.
- (b) To find ways and means to reduce adverse impacts.
- (c) To shape the project so as to suit the local environment.
- (d) To present the predictions and options to decision-makers.
- (e) To guarantee project approval regardless of

environmental damage.

Choose the most appropriate answer from the options given below:

- (1) (a), (b), (c) only
- (2) (a), (b), (c), (d) only
- (3) (b), (c), (d), (e) only
- (4) All of the above

Ans: (2)

(Questions 21-25 are based on the following passage)

Passage:

The process of biomagnification is a critical concept in ecotoxicology. It describes the increasing concentration of certain persistent substances in the tissues of organisms at successively higher levels in a food chain. For a substance to biomagnify, it must be long-lived (persistent), mobile, soluble in fats (lipophilic), and biologically active. Classic examples of substances that biomagnify are dichlorodiphenyltrichloroethane (DDT) and mercury. In aquatic ecosystems, mercury undergoes methylation by anaerobic microorganisms to form methylmercury, a highly toxic and bioavailable form. Methylmercury accumulates in phytoplankton and zooplankton, which are then consumed by small fish. These small fish are eaten by larger fish, and so on, with the concentration of methylmercury increasing at each trophic level. Top predators, such

as predatory birds (e.g., ospreys, eagles) or large fish (e.g., tuna, swordfish), and even humans, can accumulate dangerously high levels of these toxins, leading to various health issues. This phenomenon was famously documented in Minamata, Japan, where industrial discharge of mercury led to severe neurological disorders in the local population who consumed contaminated fish and shellfish. The persistence of these chemicals means they can remain in the environment for decades, posing a long-term threat.

Q21. According to the passage, which of the following properties is essential for a substance to biomagnify?

- (1) High water solubility
- (2) Short environmental half-life
- (3) High solubility in fats
- (4) Rapid biodegradation

Ans: (3)

Q22. What is the chemical form of mercury mentioned in the passage that is particularly prone to accumulation in aquatic food webs?

- (1) Elemental mercury
- (2) Mercury chloride
- (3) Methylmercury
- (4) Phenylmercury

Ans: (3)

Q23. The passage implies that the highest concentration of a biomagnifying substance would be found in:

- (1) Primary producers (phytoplankton)
- (2) Primary consumers (zooplankton)
- (3) Secondary consumers (small fish)
- (4) Tertiary or quaternary consumers (predatory birds)

Ans: (4)

Q24. The Minamata Bay disaster, as described in the passage, is a classic example of severe public health consequences caused by:

- (1) Biomagnification of DDT
- (2) A large-scale oil spill
- (3) The bioaccumulation and biomagnification of industrial mercury
- (4) Acid rain destroying aquatic life

Ans: (3)

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Q25. Assertion (A): A substance that is persistent is more likely to biomagnify.

Reason (R): Persistence allows the substance to remain in the environment long enough to be taken up by organisms and passed up the food chain without being broken down.

- (1) Both (A) and (R) are true and (R) is the correct explanation of (A), based on the context of the passage.
- (2) Both (A) and (R) are true but (R) is not the correct explanation of (A).
- (3) (A) is true but (R) is false.
- (4) (A) is false but (R) is true.

Ans: (1)

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Q26. What is the correct sequence of phases in a typical demographic transition model?

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- (a) Low birth and death rates (post-industrial)
- (b) High birth and death rates (pre-industrial)
- (c) High birth rate, declining death rate (early transitional)
- (d) Declining birth and death rates (late transitional)

Choose the correct answer from the options given below:

- (1) (b), (c), (d), (a)
- (2) (a), (b), (c), (d)
- (3) (b), (d), (c), (a)
- (4) (c), (b), (a), (d)

Ans: (1)

Q27. Which of the following is NOT a primary goal of the Convention on Biological Diversity (CBD)?

- (1) The conservation of biological diversity.
- (2) The sustainable use of its components.
- (3) The fair and equitable sharing of benefits arising out of the utilization of genetic resources.
- (4) The mandatory reduction of greenhouse gas emissions for all signatory nations.

Ans: (4)

Q28. The equivalent continuous sound level, L_{eq} , represents:

- (1) The peak sound level recorded over a period.

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(2) The average of the maximum and minimum sound levels.

(3) The sound level that would produce the same acoustic energy as the fluctuating sound level over the same period.

(4) The sound level exceeded for 90% of the measurement time.

Ans: (3)

Q29. Match List-I (ISO Standard) with List-II (Subject Matter).

List-I	List-II
(a) ISO 14001	(i) Life Cycle Assessment
(b) ISO 14020	(ii) Environmental Management Systems
(c) ISO 14040	(iii) Environmental Labels and Declarations

Choose the correct answer from the options given below:

(1) (a)-(ii), (b)-(iii), (c)-(i)

(2) (a)-(i), (b)-(ii), (c)-(iii)

(3) (a)-(iii), (b)-(i), (c)-(ii)

(4) (a)-(ii), (b)-(i), (c)-(iii)

Ans: (1)

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Q30. Given below are two statements about biofuels.
Statement I: Biodiesel is produced from vegetable oils or animal fats through a process called transesterification.

Statement II: Bioethanol is primarily produced by the fermentation of sugar-rich feedstocks, and its blending with petrol (gasohol) can reduce carbon monoxide emissions.

In light of the above statements, choose the most appropriate answer from the options given below:

- (1) Both Statement I and Statement II are correct.
- (2) Both Statement I and Statement II are incorrect.
- (3) Statement I is correct but Statement II is incorrect.
- (4) Statement I is incorrect but Statement II is correct.

Ans: (1)

Q31. Assertion (A): Laterite soils, common in tropical regions, are generally not fertile for agriculture without significant management.

Reason (R): They are formed under conditions of high temperature and heavy rainfall, which leads to intense leaching of silica and essential bases, leaving behind iron and aluminum oxides.

- (1) Both (A) and (R) are true and (R) is the correct explanation of (A).
- (2) Both (A) and (R) are true but (R) is not the correct explanation of (A).

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(3) (A) is true but (R) is false.

(4) (A) is false but (R) is true.

Ans: (1)

Q32. The 'Coriolis effect' is responsible for:

(1) The deflection of winds and ocean currents.

(2) The formation of tides.

(3) The vertical movement of air in the atmosphere.

(4) The greenhouse effect.

Ans: (1)

Q33. Arrange the following major environmental disasters in chronological order of their occurrence.

(a) Bhopal Gas Tragedy

(b) Chernobyl Nuclear Disaster

(c) Fukushima Daiichi Nuclear Disaster

(d) Minamata Disease outbreak officially recognized

Choose the correct answer from the options given

below:

(1) (d), (a), (b), (c)

(2) (a), (d), (b), (c)

(3) (d), (b), (a), (c)

(4) (b), (a), (d), (c)

Ans: (1) (Minamata-1956; Bhopal-1984; Chernobyl-1986; Fukushima-2011)

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Q34. In the logistic growth equation $dN/dt=rN(1-N/K)$, the term 'K' represents:

- (1) The intrinsic rate of increase.
- (2) The population size.
- (3) The carrying capacity of the environment.
- (4) The rate of mortality.

Ans: (3)

Q35. Which specific rule in India addresses the management of Construction and Demolition (C&D) waste?

- (1) E-Waste (Management) Rules, 2016
- (2) Hazardous Waste Management Rules, 2016
- (3) Solid Waste Management Rules, 2016
- (4) Construction and Demolition Waste Management Rules, 2016

Ans: (4)

Q36. The Poisson distribution is a statistical tool most suitably applied to model:

- (1) The normal distribution of heights in a population.
- (2) The probability of success or failure in a single trial.
- (3) The number of rare events occurring in a fixed interval of time or space.
- (4) The relationship between two continuous variables.

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Ans: (3)

Q37. Which of the following biogeochemical cycles is primarily sedimentary and has its main reservoir in the Earth's crust?

- (1) Carbon Cycle
- (2) Nitrogen Cycle
- (3) Phosphorus Cycle
- (4) Sulphur Cycle

Ans: (3)

Q38. Wind rose diagrams are used to represent:

- (1) The percentage frequency of wind speed and direction over a period.
- (2) The maximum wind gust speed recorded at a station.
- ** (3) The path of a cyclone.
- (4) The vertical profile of wind temperature.

Ans: (1)

Q39. The maximum energy conversion efficiency of a silicon-based solar photovoltaic cell is limited by the:

- (1) Wien's displacement law
- (2) Stefan-Boltzmann law
- (3) Shockley-Queisser limit
- (4) Carnot efficiency limit

Ans: (3)

Q40. The Environmental (Protection) Act, 1986 was enacted by the Parliament of India under Article 253 of the Constitution, largely as a response to the need for a general legislation and in the wake of which event/conference?

- (1) The Bhopal Gas Tragedy
- (2) The Stockholm Conference on Human Environment, 1972
- (3) The Rio Earth Summit, 1992
- (4) Both (1) and (2)

Ans: (4)

Q41. The term 'albedo' refers to:

- (1) The amount of solar radiation absorbed by a surface.
- (2) The fraction of solar radiation reflected by a surface.
- (3) The amount of infrared radiation emitted by a surface.
- (4) The heat capacity of a surface.

Ans: (2)

Q42. Which of the following statements regarding Chemical Oxygen Demand (COD) and Biochemical

Oxygen Demand (BOD) are correct?

(a) COD value is always higher than or equal to the BOD value for the same wastewater sample.

(b) BOD test measures the oxygen required for the biological oxidation of organic matter.

(c) COD test uses a strong chemical oxidant like potassium dichromate.

(d) BOD test is a rapid test that can be completed in a few hours.

Choose the correct answer from the options given below:

(1) (a), (b) and (c) only

(2) (b), (c) and (d) only

(3) (a), (c) and (d) only

(4) (a) and (d) only

Ans: (1)

Q43. Keystone species in an ecosystem are those which:

(1) Are the most abundant species.

(2) Have a disproportionately large effect on their environment relative to their abundance.

(3) Are at the top of the food chain.

(4) Are the primary producers.

Ans: (2)

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Q44. Match List-I (Geological Era) with List-II (Major Event).

List-I	List-II
(a) Cenozoic	(i) Age of Dinosaurs
(b) Mesozoic	(ii) First multicellular life
(c) Paleozoic	(iii) Age of Mammals
(d) Precambrian	(iv) First vascular plants

Choose the correct answer from the options given below:

- (1) (a)-(i), (b)-(iii), (c)-(ii), (d)-(iv)
- (2) (a)-(iii), (b)-(i), (c)-(iv), (d)-(ii)
- (3) (a)-(iii), (b)-(iv), (c)-(i), (d)-(ii)
- (4) (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii)

Ans: (2)

Q45. Assertion (A): Ocean acidification poses a significant threat to marine calcifying organisms like corals and shellfish.

Reason (R): Increased atmospheric CO₂ dissolves in ocean water, forming carbonic acid, which reduces the pH and decreases the saturation state of carbonate ions (CO₃²⁻) needed for shell and skeleton formation.

- (1) Both (A) and (R) are true and (R) is the correct explanation of (A).
- (2) Both (A) and (R) are true but (R) is not the correct explanation of (A).

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(3) (A) is true but (R) is false.

(4) (A) is false but (R) is true.

Ans: (1)

Q46. The 'dose-response' relationship in toxicology is used to determine:

(1) The rate of absorption of a toxicant.

(2) The pathway of a toxicant in the body.

(3) The intensity of a toxicant's effect at different doses.

(4) The half-life of a toxicant in the environment.

Ans: (3)

Q47. In India, the National Ambient Air Quality Standards (NAAQS) include which of the following pollutants?

(a) SO₂

(b) NO₂

(c) O₃

(d) Benzene

(e) CO₂

Choose the correct answer from the options given below:

(1) (a), (b), (c) only

(2) (a), (b), (c), (d) only

(3) (b), (c), (d), (e) only

(4) All of the above

Ans: (2) (CO₂ is not a criteria pollutant in NAAQS)

Q48. The technology used for flue-gas desulfurization (FGD) in thermal power plants primarily involves:

- (1) Adsorption using activated carbon.
- (2) Catalytic conversion using a platinum catalyst.
- (3) Wet scrubbing using a lime or limestone slurry.
- (4) High-temperature incineration.

Ans: (3)

Q49. A Type I error in hypothesis testing occurs when:

- (1) We reject a true null hypothesis.
- (2) We fail to reject a false null hypothesis.
- (3) We reject a false null hypothesis.
- (4) We fail to reject a true null hypothesis.

Ans: (1)

Q50. The Ramsar Convention is an international treaty for:

- (1) The conservation and sustainable use of wetlands.
- (2) The protection of the ozone layer.
- (3) The control of transboundary movements of hazardous wastes.
- (4) The protection of migratory species.

Ans: (1)



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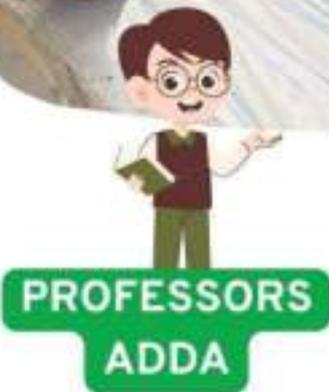


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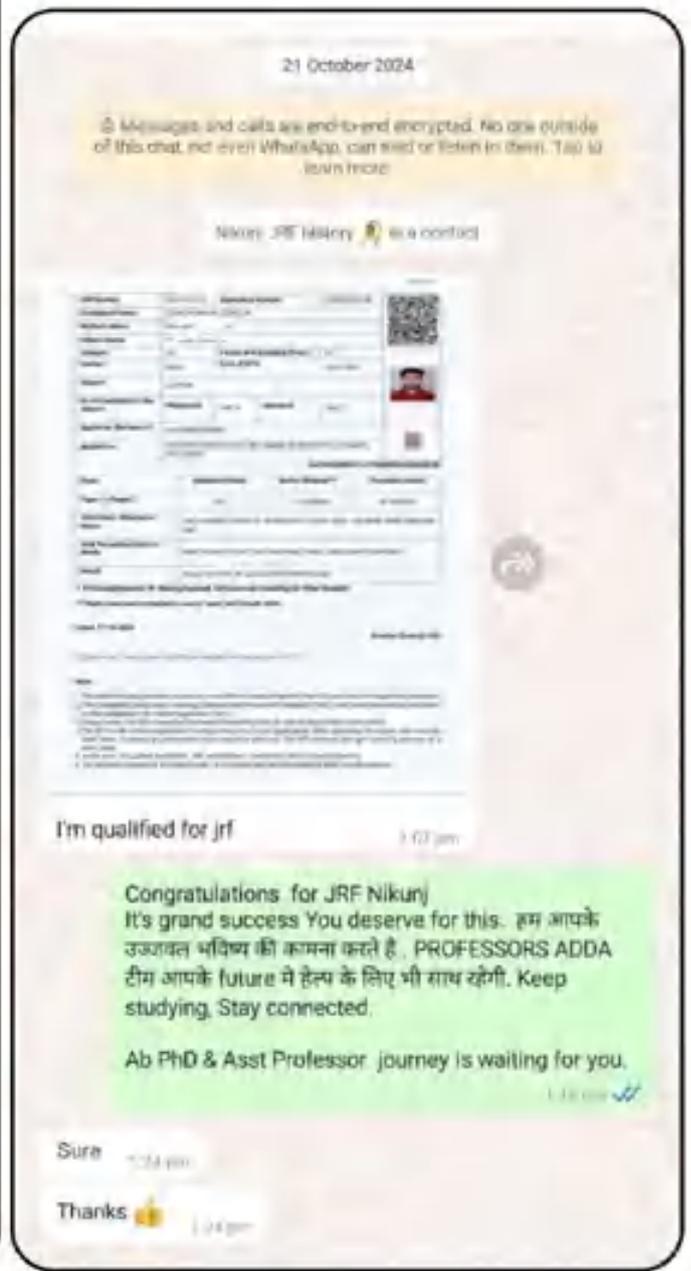
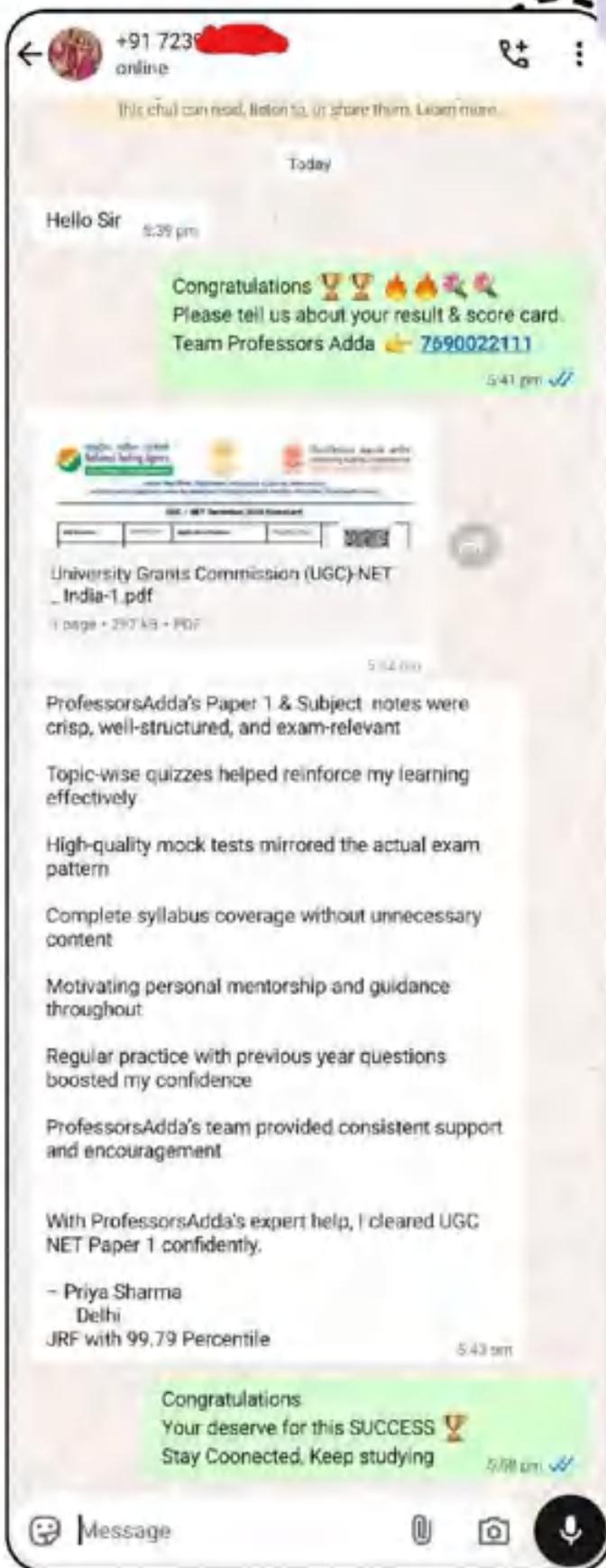
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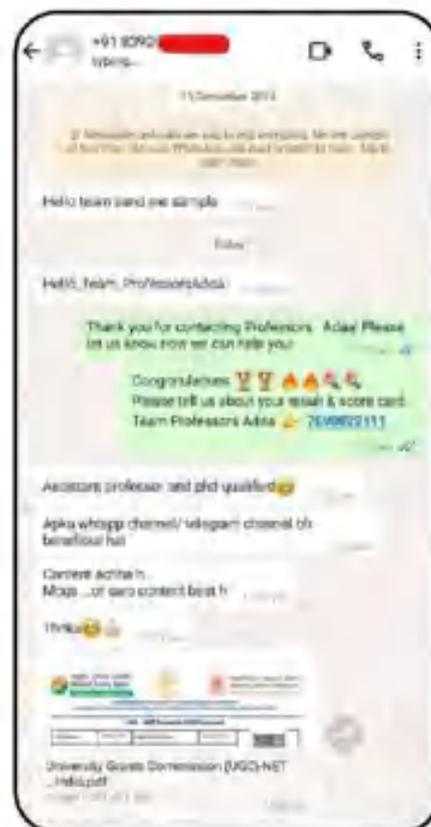
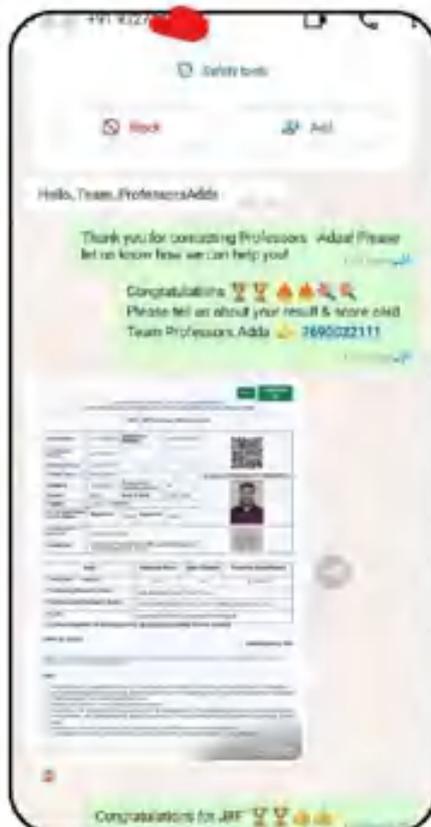
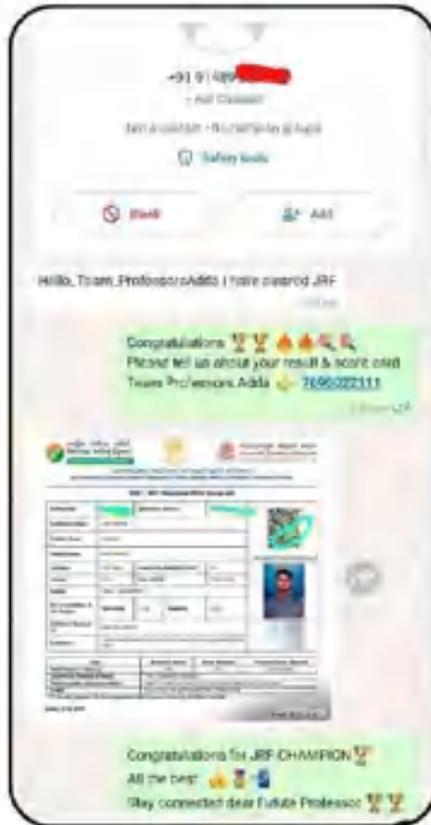
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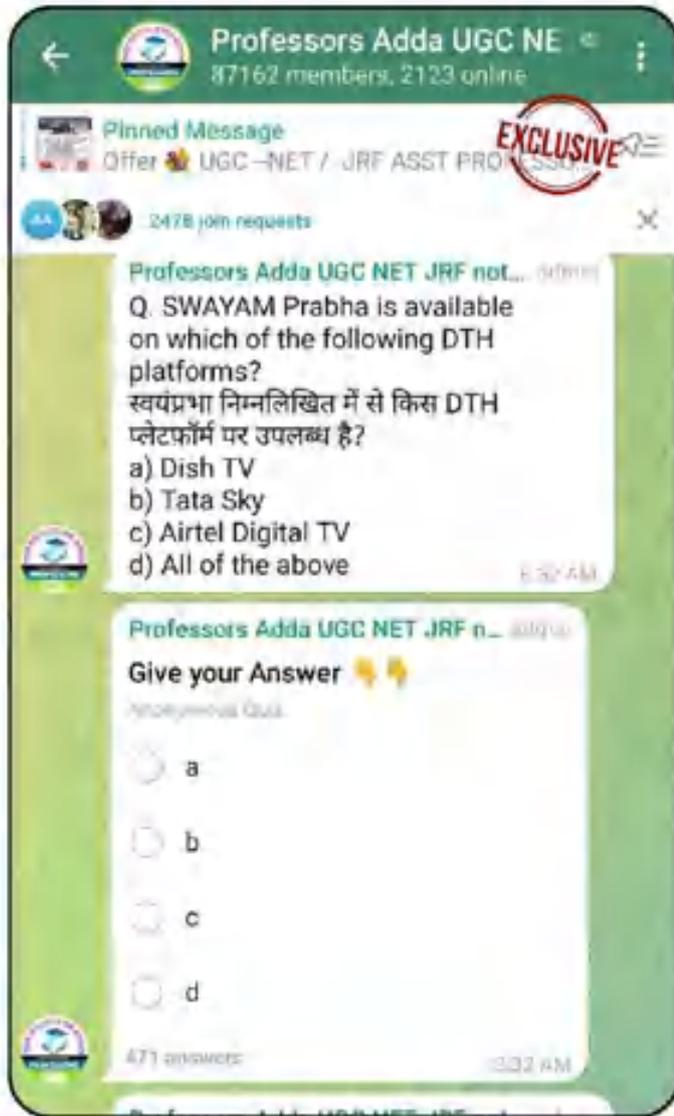
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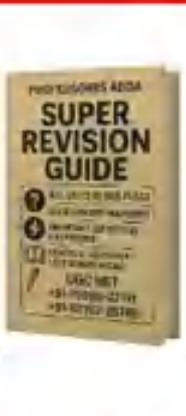
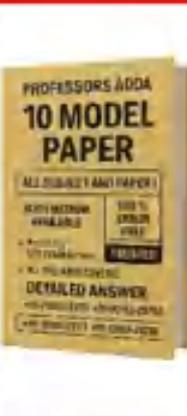
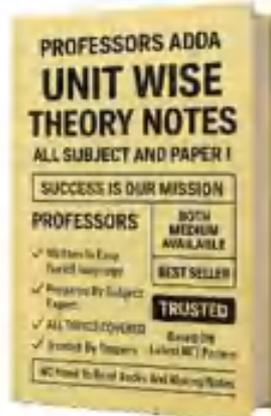
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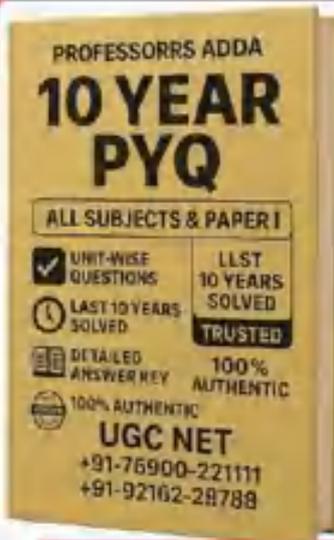
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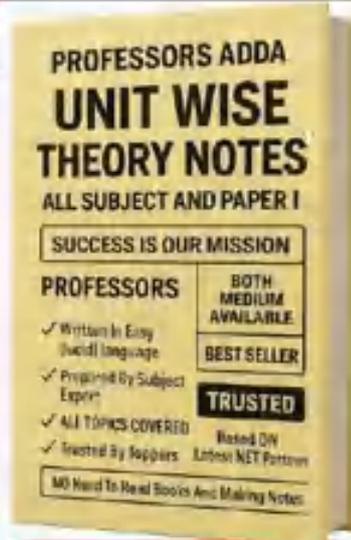
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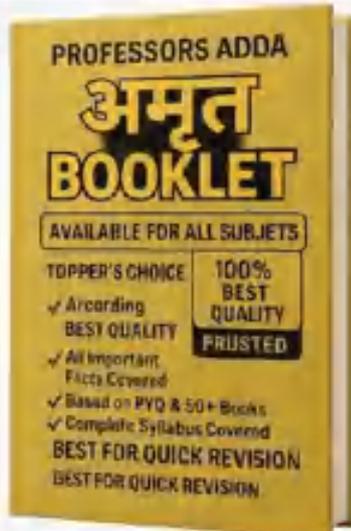
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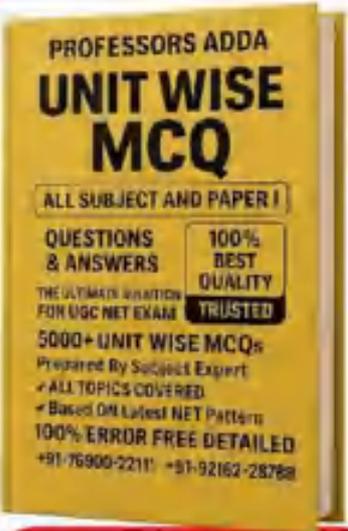
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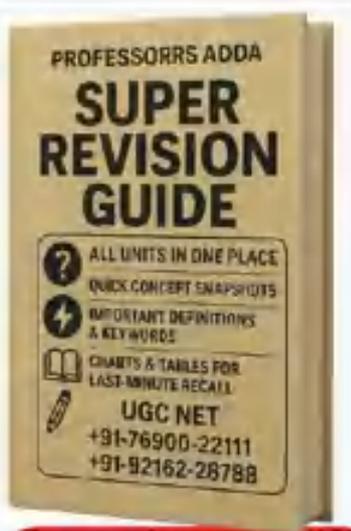
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