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PART-A

1. "To achieve the desired goal of Sustainable Development, societies have to make certain transitions which are very much essential." Justify the statement in about 250 words

Answer: The statement is fundamentally correct. Sustainable Development, which seeks to meet present needs without compromising the ability of future generations to meet their own, is an ideology of balance. Our current global societies, however, are largely built on "business-as-usual" models that are inherently *unsustainable*. These models rely on linear consumption (take-make-dispose), intensive fossil fuel use, and assume infinite resources on a finite planet.

These practices directly undermine the well-being of future generations, thus "transitions" are not merely optional improvements but essential, non-negotiable structural shifts required to achieve sustainability.

Key essential transitions include:

- **The Energy Transition:** A shift from a high-carbon, fossil-fuel-based economy to one centered on renewable and low-carbon energy. This is essential to mitigate climate change (driven by CO_2 emissions) and preserve a habitable planet.
- **The Economic Transition:** A shift from a linear economy to a **Circular Economy**. This moves away from wasteful consumption towards a system of reuse, repair, remanufacturing, and recycling, ensuring resource availability for the future.
- **The Social Transition:** A move from societies with high levels of inequality and exclusion towards greater equity, justice, and inclusion. A society that fails to meet the present needs of all its members is socially unstable and, therefore, unsustainable.

In conclusion, because our current trajectory is unsustainable, we must undergo these profound transitions in our energy, economic, and social systems. They are the only practical mechanisms for achieving the desired goal of Sustainable Development.

2. Differentiate between the following terms by giving suitable examples in about 125 words

- (a) Primary and secondary succession:

Answer: **Primary succession** occurs in an essentially lifeless area where no community existed before, and crucially, *no soil is present*. It begins on bare substrates like new volcanic rock, sand dunes, or surfaces exposed by retreating glaciers. The process is extremely slow, as it must start with pioneer species, such as lichens and mosses. These organisms break down the rock to create the very first layer of soil, which eventually allows larger plants like grasses and shrubs to establish, followed centuries later by trees. A classic example is the colonization of a new lava flow after a volcanic eruption. **Secondary succession**, in contrast, occurs in an area where a pre-existing community has been disturbed or destroyed, but the *soil remains intact*. Common disturbances include forest fires, logging, hurricanes, or abandoned agricultural fields. Because fertile soil and a seed bank are already present, this process is much faster than primary succession. Pioneer species are typically grasses and weeds, which are quickly followed by shrubs and then fast-growing trees, eventually leading back to a climax community. A clear example is a forest regrowing after a wildfire.

- (b) Direct and indirect use value of biodiversity:

Answer: **Direct use value** refers to the tangible, consumptive benefits that humans directly harvest or extract from biodiversity. These are resources that have a clear economic or livelihood value. Examples include *consumptive uses* like timber for construction, fuelwood for energy, medicinal plants, and food resources such as fish, wild game, and agricultural crops. It also includes *productive uses* where products are commercially harvested and sold. **Indirect use value**, in contrast, refers to the non-consumptive benefits derived from the *services* that ecosystems provide, rather than a physical product. These services are essential for human survival and well-being, though often not given a monetary value. Examples include the pollination of crops by bees and insects, oxygen production by forests, climate regulation (CO_2 absorption) by ecosystems, natural water purification by wetlands, and flood control provided by mangrove forests.

3. Answer the following questions in about 150 words each.

(a) What is biodiversity hotspot? Why is India considered as a mega biodiversity hotspot?

Answer: A **biodiversity hotspot** is a biogeographic region that is both a significant reservoir of biodiversity and is under severe threat of destruction. The concept was defined by Norman Myers and requires a region to meet two strict criteria:

- i. It must contain at least 1,500 species of vascular plants ($> 0.5\%$ of the world's total) as *endemics*, meaning they are found nowhere else on Earth.
- ii. It must have lost at least 70% of its original natural vegetation, indicating a high level of threat.

These hotspots are critical, high-priority areas for global conservation efforts.

India is considered a **mega biodiversity country** (one of only 17 in the world) because it possesses an exceptionally high variety of life forms. This is due to its diverse geography, which includes the Himalayan mountains, the Western and Eastern Ghats, coastal areas, deserts, and fertile plains.

More specifically, India hosts *four* of the world's 36 designated biodiversity hotspots:

- The Himalayas
- The Western Ghats
- The Indo-Burma region (covering North-Eastern India)
- Sundaland (covering the Nicobar Islands)

These regions, like the Western Ghats, are exceptionally rich in endemic species (especially plants, amphibians, and reptiles) while also facing intense pressure from habitat loss and human activity. This combination of high endemism and extreme threat across multiple regions confirms India's status as a critical global center for biodiversity.

(b) Describe the life forms of aquatic ecosystem found in different zones with suitable examples and diagrams.

Answer: Aquatic ecosystems, such as lakes or ponds, are zoned both by light penetration and by distance from shore. The life forms are adapted to the conditions of each zone.

Life is broadly categorized as:

- **Plankton:** Microscopic, free-floating organisms. Includes *phytoplankton* (producers like algae) and *zooplankton* (consumers like copepods).
- **Nekton:** Actively swimming organisms, like fish and amphibians.
- **Benthos:** Bottom-dwelling organisms, like snails, worms, and bacteria.

These life forms are distributed across the following zones:

- i. **Littoral Zone:** This is the shallow, near-shore area where sunlight penetrates all the way to the bottom. It has the highest biodiversity.
 - **Examples:** Rooted plants (macrophytes) like cattails and water lilies dominate. It is rich in benthos (snails, clams, insect larvae), nekton (frogs, tadpoles, small fish), and plankton.
- ii. **Limnetic Zone:** This is the open, sunlit (photic) surface water away from the shore.
 - **Examples:** This zone is dominated by plankton. Phytoplankton (algae) are the primary producers. Zooplankton feed on them. Nekton (larger fish like trout or bass) swim freely in this zone.
- iii. **Profundal Zone:** This is the deep, cold, dark (aphotic) layer of water where sunlight cannot reach.

- **Examples:** Life here is sparse and consists of consumers (nekton like specialized fish) and decomposers that depend on the "rain" of dead organic matter (detritus) from the zones above.
- iv. **Benthic Zone:** This refers to the entire bottom substrate (sediment) of the ecosystem, spanning all the zones above.
- **Examples:** This zone is dominated by benthos. In the sunlit littoral part, it includes rooted plants and algae. In the deep profundal part, it is populated by decomposers (bacteria, fungi) and detritivores (like worms) adapted to low oxygen and cold.
- (c) Differentiate between the surface and ground water. Describe the factors responsible for degradation of water.

Answer: **Surface water** is any body of water found on the Earth's surface, such as rivers, lakes, streams, ponds, and reservoirs. Its primary source is precipitation (rain and snowmelt) that collects in these bodies, known as surface runoff. It is easily accessible for human use but is also highly vulnerable to evaporation and direct contamination from pollution.

Groundwater is water held underground in the soil or in pores and crevices in rock formations. It originates from surface water (like rain) that seeps into the ground, a process called infiltration. This water collects in underground layers called aquifers. It is generally less accessible, requiring wells or pumps, but it is naturally filtered by the soil and rock layers, making it less prone to pollution than surface water.

The **factors responsible for the degradation of water** (both surface and groundwater) are primarily anthropogenic:

- **Agricultural Runoff:** The use of chemical fertilizers (nitrates, phosphates) and pesticides in farming. When it rains, these chemicals are washed from the fields into nearby rivers and lakes, causing eutrophication (algal blooms) and contaminating drinking water.
- **Industrial Discharge:** Factories and industrial plants often release untreated toxic waste (effluents) directly into water bodies. These wastes can contain heavy metals (like mercury, lead), solvents, and other hazardous chemicals that are toxic to aquatic life and humans.
- **Sewage and Wastewater:** Inadequate treatment of domestic sewage from households and cities releases human waste, pathogens (bacteria, viruses), and organic matter into water. This depletes the water's dissolved oxygen, killing fish, and spreads waterborne diseases.
- **Urban Runoff:** Stormwater from cities washes pollutants like oil, grease, heavy metals from vehicles, and trash from roads and parking lots directly into water systems.
- **Oil Spills and Leakage:** Accidental spills from tankers, pipelines, or leaking underground storage tanks can release petroleum products, which are extremely difficult to clean up and are devastating to marine and freshwater ecosystems.

- (d) Write a short note on carbon cycle with the help of a diagram.

Answer: The **carbon cycle** is the biogeochemical process through which carbon is exchanged among the four major reservoirs of the Earth: the atmosphere (air), the biosphere (living organisms), the hydrosphere (oceans, water), and the lithosphere (earth, rocks). Carbon, primarily as carbon dioxide (CO_2), is the fundamental building block of life.

The cycle involves several key processes:

- **Photosynthesis:** This is the primary pathway for carbon to enter the biosphere. Plants, algae, and cyanobacteria absorb CO_2 from the atmosphere (or water) and use sunlight to convert it into energy-rich organic compounds (glucose).

- **Respiration:** Living organisms (both plants and animals) release CO_2 back into the atmosphere through cellular respiration, the process of breaking down organic compounds to release energy.
- **Decomposition:** When organisms die, decomposers like bacteria and fungi break down their organic matter. This process also releases CO_2 into the atmosphere. Over long geological periods, some of this carbon can be buried and form fossil fuels (coal, oil, gas) in the lithosphere.
- **Combustion:** The burning of organic matter, such as in wildfires or, most significantly, the human burning of fossil fuels, rapidly releases vast amounts of stored carbon back into the atmosphere as CO_2 .
- **Ocean Exchange:** The oceans are a massive carbon sink. CO_2 from the atmosphere dissolves in seawater. It is used by marine organisms (for photosynthesis or to build shells) and can also sink to the deep ocean, where it is stored for long periods.

This cycle maintains a balance of carbon, but human activities, especially combustion, have significantly increased atmospheric CO_2 , leading to global climate change.

4. How does Forest Right Act, 2006 help tribal and forest dwellers in India? Explain with suitable examples in about 200 words.

Answer: The **Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006**, commonly known as the **Forest Rights Act (FRA)**, is a landmark piece of legislation that fundamentally helps tribal and forest-dwelling communities by legally recognizing and securing their pre-existing rights. Its core purpose is to rectify the "historical injustice" these communities faced, as their traditional homes and livelihoods were often treated as 'encroachments' by forest authorities.

The Act empowers these communities in several crucial ways. First, it provides **Individual Forest Rights (IFR)**, granting a legal title (*patta*) to land that families have been cultivating or living on for generations. For example, a tribal family in Chhattisgarh that has farmed a plot for decades without legal papers can now claim legal ownership, protecting them from arbitrary eviction. Secondly, and perhaps most significantly, it recognizes **Community Forest Resource (CFR) Rights**. This gives the entire village community, through its *Gram Sabha*, the collective right to manage, protect, and sustainably use their traditional forests. For instance, a *Gram Sabha* in Odisha can use this right to manage and sell bamboo or tendu leaves, securing their community's livelihood and preventing exploitation. This provision, along with the affirmed right to collect and sell **Minor Forest Produce (MFP)** like honey and herbs, shifts the role of forest dwellers from passive subjects to empowered rights-holders, ensuring both their livelihood security and the conservation of their ancestral forests.

5. Critically evaluate the status of non-conventional energy resources in India. Elucidate your answer with suitable examples in about 200 words.

Answer: India's status regarding non-conventional (renewable) energy resources is one of **rapid, large-scale expansion** driven by strong government policy, yet it faces critical challenges in infrastructure and integration. India has emerged as a global leader in the green energy transition, recognizing that renewables are essential for its energy security, climate commitments, and economic growth.

The primary focus has been on **solar energy**, propelled by the National Solar Mission. This has resulted in an exponential growth of installed solar capacity. A prime example is the development of massive-scale projects like the *Bhadla Solar Park* in Rajasthan, one of the largest in the world. Alongside solar, India has a mature **wind power** sector, with states like Tamil Nadu and Gujarat hosting extensive wind farms that contribute significantly to the grid. The government is also actively promoting other sources like bio-energy and small-hydro projects.

Critically, this aggressive expansion faces significant hurdles. The most prominent is the *intermittency* of solar and wind power—they are not available 24/7. This creates a major need for grid-scale energy storage solutions (like large batteries), which are currently very expensive. Furthermore, upgrading the national grid to handle these fluctuating power sources and acquiring the large tracts of land needed for solar and wind farms present substantial logistical and social challenges.

In conclusion, while India's progress in non-conventional energy is highly commendable and globally significant, its status is that of a nation in a dynamic but challenging transition.

PART-B

6. Explain the following terms in about 60 words each:

(a) **Ecofeminism**

Answer: Ecofeminism is an intellectual and social movement that links feminism with ecology. It explores the conceptual connections between the domination of nature (environmental degradation) and the subordination of women (patriarchy). Ecofeminists argue that both oppressions stem from the same male-dominated, hierarchical worldview that values exploitation over nurturing, and that the liberation of one is tied to the liberation of the other.

(b) **Geographical and Social Inequity**

Answer: Geographical inequity refers to the uneven distribution of resources, opportunities, and well-being across different places (e.g., urban vs. rural, Global North vs. Global South). Social inequity refers to the unfair distribution of these same factors within a society, based on class, gender, race, or caste. The two are often linked, as marginalized social groups are frequently forced to live in geographically vulnerable areas, such as polluted industrial zones or flood-plains.

(c) **Ozone layer depletion**

Answer: Ozone layer depletion is the thinning of the stratospheric ozone (O_3) layer, which shields the Earth from the sun's harmful ultraviolet (UV-B) radiation. This depletion is primarily caused by human-made chemicals, especially chlorofluorocarbons (CFCs), once used in aerosols and refrigerants. The release of these chemicals leads to chemical reactions in the stratosphere that destroy ozone molecules, increasing the amount of UV radiation reaching the surface.

(d) **Acid Rain**

Answer: Acid rain is any form of precipitation (rain, snow, fog) that is unusually acidic, meaning it has a low pH. It is caused when sulfur dioxide (SO_2) and nitrogen oxides (NO_x)—gases released primarily from burning fossil fuels in power plants and vehicles—react with water, oxygen, and other chemicals in the atmosphere. These reactions form sulfuric and nitric acids, which then fall to the ground, harming forests, lakes, and buildings.

7. Answer the following questions in about 150 words each:

(a) **Explain any four impacts of improper waste disposal with suitable examples.**

Answer: Improper waste disposal has severe environmental and public health impacts.

- i. **Soil Contamination:** When hazardous wastes from industries or households (like batteries, paint, or chemicals) are dumped in open land, they leach toxic substances (leachate) into the soil. This contamination renders the land infertile and unsafe for agriculture.
- ii. **Water Pollution:** The same leachate can seep deep into the ground and contaminate groundwater aquifers, which are a critical source of drinking water. Furthermore, dumping solid waste directly into rivers or lakes pollutes surface water, killing aquatic life and spreading waterborne diseases like cholera and typhoid.
- iii. **Air Pollution:** The decomposition of organic waste in open dumpsites releases methane (CH_4), a potent greenhouse gas, and hydrogen sulfide (H_2S), which causes foul odors. Additionally, the uncontrolled burning of this waste releases dioxins, furans, and carbon monoxide, which are toxic air pollutants.
- iv. **Public Health Hazards:** Open dumps attract disease vectors such as rats, flies, and mosquitoes. These pests can transmit diseases (like plague or dengue fever) to nearby human populations. Direct contact with waste by waste-pickers can also lead to skin infections and physical injuries.

(b) How does landfilling act as an important method of waste disposal? Explain.

Answer: Landfilling is a method of waste disposal where waste is buried in the ground. While older, open dumps are a source of pollution, *sanitary landfills* are engineered facilities that act as an important method for isolating non-recyclable, non-compostable solid waste from the environment.

Their importance comes from their design. A modern sanitary landfill is built with a composite liner system at the bottom, typically made of high-density plastic (HDPE) and compacted clay. This liner prevents toxic *leachate* (the liquid that seeps through waste) from contaminating groundwater.

Furthermore, a leachate collection system is installed to pump out this liquid, which is then sent to a treatment plant. As the organic waste decomposes, it produces landfill gas (mostly methane). This gas is also collected via a system of pipes. Instead of letting it escape and contribute to climate change, it can be flared (burned off) or, ideally, captured and used as a source of energy.

Finally, when the landfill is full, it is "capped" with a cover to seal the waste in. Landfilling is thus an important and necessary final disposal step for waste that cannot be managed by other means.

(c) Describe the role of Central Pollution Control Board (CPCB) as an institution for monitoring the pollution levels of the environment.

Answer: The Central Pollution Control Board (CPCB) is India's apex statutory organization responsible for environmental protection. Its primary role in monitoring pollution is to provide technical services to the Ministry of Environment, Forest and Climate Change and to coordinate the activities of the State Pollution Control Boards (SPCBs).

The CPCB's key monitoring functions include:

- **Setting Standards:** It lays down and uniform standards for the quality of air and water, as well as for the emission or discharge of environmental pollutants from various industries.
- **National Monitoring Networks:** The CPCB runs extensive nationwide monitoring programs. For example, the National Air Quality Monitoring Programme (NAMP) and the National Water Quality Monitoring Programme (NWMP) involve a network of monitoring stations across the country.
- **Data Collection and Dissemination:** These stations collect ambient data on key pollutants (like $PM_{2.5}$, SO_2 , NO_x in air, and BOD , DO in water). The CPCB compiles, analyzes, and disseminates this data to the public (e.g., through the Air Quality Index or AQI), government, and researchers to assess pollution trends and the effectiveness of control measures.

In essence, the CPCB acts as the nation's "watchdog," providing the scientific data and technical framework necessary to understand and manage pollution levels across the country.

(d) How do collective actions help in addressing environmental issues and concerns? Explain.

Answer: Collective actions, where groups of individuals organize and act together, are a powerful force for addressing environmental issues that often seem too large or systemic for any one person to solve.

Firstly, collective action creates **political pressure**. When a community, an NGO, or a public movement (like 'Fridays for Future') raises its voice, it can influence government policy and corporate behavior far more effectively than isolated individuals. This can lead to the creation of new environmental laws, the enforcement of existing ones, or the cancellation of ecologically destructive projects.

Secondly, collective action allows for **pooled resources and large-scale impact**. Community-led initiatives like tree-planting drives, river clean-up campaigns (e.g., the cleanup of the Versova beach in Mumbai), or the establishment of local recycling programs can achieve tangible, on-the-ground results that would be impossible alone.

Thirdly, these actions build **social awareness and norms**. When a community works together to protect its environment, it reinforces shared values of conservation and sustainability. This social

learning and solidarity can lead to lasting changes in behavior and consumption patterns, fostering a resilient, environmentally-conscious society.

8. "Habitat destruction is recognized as most significant threat to global biodiversity." Elucidate the statement with respect to present day context in about 200 words.

Answer: This statement is accurate because habitat destruction is the most direct, pervasive, and irreversible driver of extinction. Unlike other threats, it does not just harm a species; it eliminates the entire physical ecosystem that the species requires for survival, including food, shelter, and breeding.

In the present-day context, this destruction is driven relentlessly by human activities. The primary driver is agriculture, where vast, biodiverse ecosystems like the Amazon rainforest are cleared for cattle ranching and soy or palm oil plantations. Secondly, rapid urbanization and large-scale infrastructure projects (dams, highways, mining) physically pave over or fragment natural areas. This fragmentation isolates populations, shrinks genetic diversity, and blocks migratory routes, making species critically vulnerable.

For example, the conversion of wetlands for coastal development destroys vital nurseries for marine life, while deforestation in Borneo directly pushes species like the orangutan towards extinction. While climate change or pollution are also severe threats, habitat destruction is the immediate, foundational cause that pushes the largest number of species to the brink.

9. "Polluted water is a threat to our health and survival of life forms" Explain it with respect to different agents of water pollutants in about 200 words.

Answer: Polluted water is a direct threat because water is a universal solvent and a fundamental requirement for all life. When contaminated, it becomes a potent delivery mechanism for toxins and disease.

For human health, the threat is twofold. **Biological pollutants**, such as bacteria (like *Vibrio cholerae*) and viruses from untreated sewage, cause acute waterborne diseases like cholera, typhoid, and dysentery. **Chemical pollutants** pose a chronic, cumulative threat. For example, industrial discharges release heavy metals like mercury and lead. These are neurotoxins that *bioaccumulate* in the food chain, poisoning fish and, ultimately, humans, causing severe neurological damage. Similarly, agricultural runoff introduces excess nitrates, which can contaminate drinking water and cause "blue baby syndrome" in infants.

For other life forms, these pollutants are equally devastating. Chemical agents like pesticides are directly toxic to aquatic organisms. Nutrient pollutants (nitrates and phosphates from fertilizers) cause *eutrophication*—massive algal blooms that deplete the water's dissolved oxygen, creating "dead zones" that suffocate all aquatic life, from fish to plants.

10. "The ratio of those killed to those affected by natural disasters depend on the type of calamity, degree of preparedness and the density of population" Justify the statement with suitable examples in about 250 words.

Answer: This statement is entirely correct because the human impact of a natural disaster is not defined by its physical magnitude alone, but by its direct interaction with human vulnerability. The "ratio of killed to affected" is a stark measure of this vulnerability.

First, the **type of calamity** sets the baseline risk. A sudden-onset disaster like an earthquake or a tsunami offers almost no warning time, often resulting in a high ratio of fatalities. In contrast, a slow-onset disaster like a drought or a well-forecasted flood may affect millions (e.g., crop loss, displacement) but have a much lower immediate death toll.

Second, the **degree of preparedness** is the most critical variable, explaining why the same event has vastly different outcomes in different places. For example, the 2010 Haiti earthquake (magnitude 7.0) killed over 100,000 people due to a near-total lack of building codes and emergency response infrastructure. Conversely, the 2011 Japan earthquake (magnitude 9.0) was exponentially more powerful, yet strict building codes, advanced tsunami warning systems, and well-trained emergency services resulted in a far lower ratio of deaths to the millions affected.

Finally, **density of population** acts as a risk multiplier. A powerful cyclone striking a densely populated coastal city in Bangladesh will inherently endanger more lives than an identical storm hitting a sparsely

populated Australian coastline. High population density in high-risk zones, such as slums on unstable hillsides, dramatically increases the casualty ratio when a disaster (like a mudslide) occurs.