Environment and Sustainability Solutions

4300003 – Winter 2023

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [03 marks]

Explain ecological footprint.

Solution

Ecological footprint measures the demand on nature by individuals, communities, or nations in terms of biologically productive land and water area required to sustain their lifestyle.

Table 1: Components of Ecological Footprint

Component	Description
Carbon Footprint	Land needed to absorb CO emissions
Cropland	Area for food production
Grazing Land	Area for livestock
Forest Products	Area for timber and paper
Built-up Land	Infrastructure and urban areas

- **Global hectares**: Standard unit for measurement
- **Overshoot**: When footprint exceeds biocapacity
- **Sustainability**: Balance between consumption and regeneration

Mnemonic

"CGFBB" - Carbon, Cropland, Grazing, Forest, Built-up

Question 1(b) [04 marks]

Explain Eltonian pyramid.

Solution

Eltonian pyramid (Pyramid of Numbers) shows the number of organisms at each trophic level in an ecosystem, proposed by Charles Elton.

Diagram:

```
Tertiary Consumers
(Few {- 10)}

Secondary Consumers
(Moderate {- 100)}

Primary Consumers
(Many {- 1000)}

Producers
(Maximum {- 10000)}
```

Table 2: Pyramid Types

Type	Basis	Shape
Numbers	Individual count	Usually upright

Biomass	Total weight	Can be inverted
Energy	Energy flow	Always upright

- **Trophic levels**: Feeding positions in food chain
- **10% rule**: Only 10% energy transfers to next level
- **Exceptions**: Tree ecosystem shows inverted number pyramid

Mnemonic

"ELTON" - Energy Loss Through Organism Numbers

Question 1(c) [07 marks]

Explain Eco-system with its classification and component.

Solution

Ecosystem is a functional unit of nature where living organisms interact with each other and their physical environment, involving energy flow and nutrient cycling.

Table 3: Ecosystem Components

Component	Type	Examples
Abiotic	Non-living	Air, water, soil, climate
Biotic	Living	Plants, animals, microorganisms
Producers	Autotrophs	Green plants, algae
Consumers	Heterotrophs	Herbivores, carnivores, omnivores
Decomposers	Recyclers	Bacteria, fungi

Classification of Ecosystems:
Natural Ecosystems:
- **Terrestrial**: Forest, grassland, desert
- **Aquatic**: Freshwater (pond, river), Marine (ocean, sea)

Artificial Ecosystems:
- **Agricultural**: Crop fields, gardens
- **Urban**: Parks, artificial lakes

Diagram: Energy Flow

```
flowchart LR
    A[Sun] {-{-} B[Producers]}
    B {-{-} C[Primary Consumers]}
    C {-{-} D[Secondary Consumers]}
    D {-{-} E[Tertiary Consumers]}
    F[Decomposers] {-{-} B}
    C {-{-} F}
    D {-{-} F}
    E {-{-} F}
```

- **Energy flow**: Unidirectional from sun to decomposers
- **Nutrient cycling**: Cyclical movement of elements
- **Food chains**: Linear energy transfer
- **Food webs**: Interconnected food chains

Mnemonic

"PEACE" - Producers, Energy, Animals, Cycles, Environment

Question 1(c OR) [07 marks]

Explain Nitrogen cycle.

Solution

Nitrogen cycle is the biogeochemical cycle that converts nitrogen compounds through various chemical forms as it circulates through atmosphere, terrestrial and aquatic systems.

Diagram: Nitrogen Cycle

```
flowchart LR
    A[Atmospheric N ] {-{-} B[Nitrogen Fixation]}
    B {-{-} C[Ammonia NH ]}
    C {-{-} D[Nitrification]}
    D {-{-} E[Nitrites NO ]}
    E {-{-} F[Nitrates NO ]}
    F {-{-} G[Plant Uptake]}
    G {-{-} H[Animal Consumption]}
    H {-{-} I[Decomposition]}
    I {-{-} C}
    F {-{-} J[Denitrification]}
    J {-{-} A}
```

Table 4: Nitrogen Cycle Processes

Process	Conversion	Organisms
Fixation	N → NH	Rhizobium, Azotobacter
Nitrification	NH → NO → NO	Nitrosomonas, Nitrobacter
Assimilation	NO → Proteins	Plants
Decomposition	Proteins → NH	Bacteria, fungi
Denitrification	NO → N	Anaerobic bacteria

- **Biological fixation**: 80% of total fixation
- **Industrial fixation**: Haber process for fertilizers
- **Lightning**: Natural atmospheric fixation
- **Pollution**: Excess nitrates cause eutrophication

Mnemonic

"FNADD" - Fixation, Nitrification, Assimilation, Decomposition, Denitrification

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Question 2(a) [03 marks]

List the waste water quality parameter.

Solution

Table 5: Wastewater Quality Parameters

Physical	Chemical	Biological
Turbidity	**BOD**	**Coliform count**
Color	**COD**	**Pathogenic bacteria**
Odor	**pH**	**Algae**
Temperature	**DO**	**Virus**
Total Solids	**Ammonia**	**Protozoa**

- **Primary parameters**: BOD, COD, pH, suspended solids
- **Secondary parameters**: Heavy metals, nutrients
- **Indicator organisms**: E.coli for fecal contamination

Mnemonic

"PCB" - Physical, Chemical, Biological parameters

Question 2(b) [04 marks]

Explain E-waste classification and effects.

Solution

Electronic waste (E-waste) refers to discarded electrical and electronic equipment containing hazardous materials.

Table 6: E-waste Classification

Category	Examples	Hazardous Materials
Large Appliances	Refrigerators, washing machines	CFCs, heavy metals
Small Appliances	Microwaves, toasters	Lead, mercury
IT Equipment	Computers, printers	Cadmium, chromium
Telecom Equipment	Mobile phones, cables	Beryllium, flame retardants
Consumer Electronics	TVs, radios	Polyvinyl chloride (PVC)

Effects of E-waste:

- **Environmental**: Soil and water pollution, air contamination
- **Health**: Cancer, neurological disorders, respiratory problems
- **Resource depletion**: Loss of valuable metals like gold, silver
- **Ecosystem damage**: Bioaccumulation in food chain

Mnemonic

"LSITC" - Large, Small, IT, Telecom, Consumer electronics

Question 2(c) [07 marks]

Explain Electrostatic precipitators.

Solution

Electrostatic precipitators (ESP) are air pollution control devices that remove particulate matter from industrial gas streams using electrical charges.

Diagram: ESP Working

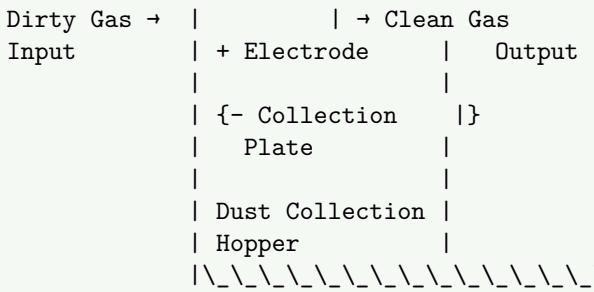

Table 7: ESP Components and Functions

Component	Function	Material
Discharge Electrode	Creates corona discharge	Tungsten wire
Collection Plate	Attracts charged particles	Steel plates

High Voltage Supply	Provides 30-100 kV DC	Transformer-rectifier
Rapper System	Removes collected dust	Mechanical vibrator
Hopper	Collects fallen particles	Steel container

Working Principle:

1. **Ionization**: High voltage creates corona discharge
2. **Charging**: Particles acquire negative charge
3. **Collection**: Charged particles move to positive plates
4. **Removal**: Rapping dislodges collected dust

Applications:

- **Power plants**: Coal-fired boilers
- **Cement industry**: Kiln gas cleaning
- **Steel industry**: Blast furnace gas
- **Chemical plants**: Process gas treatment

Advantages:

- **High efficiency**: 99%+ removal for fine particles
- **Low pressure drop**: Energy efficient operation
- **Handles high temperatures**: Up to 400°C

Mnemonic

"CHARGE" - Corona, High-voltage, Attract, Rapper, Gas, Efficiency

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Question 2(a OR) [03 marks]

Explain (1) BOD (2) COD

Solution

Table 8: BOD vs COD

Parameter	BOD	COD
Full Form	Biochemical Oxygen Demand	Chemical Oxygen Demand
Method	Biological oxidation	Chemical oxidation
Time	5 days at 20°C	2-3 hours
Oxidizing Agent	Microorganisms	Potassium dichromate

(1) BOD (Biochemical Oxygen Demand):

- **Definition**: Oxygen required by microorganisms to decompose organic matter
- **Standard conditions**: 5 days, 20°C, dark conditions
- **Units**: mg/L or ppm

(2) COD (Chemical Oxygen Demand):

- **Definition**: Oxygen equivalent to oxidize organic matter chemically
- **Oxidizing agent**: K Cr O in acidic medium
- **Higher than BOD**: Includes non-biodegradable compounds

Mnemonic

"BTCO" - Biological Time, Chemical Oxidation

Question 2(b OR) [04 marks]

Explain Recycle of E waste.

Solution

E-waste recycling is the process of recovering valuable materials from electronic waste while safely disposing of hazardous substances.

Table 9: E-waste Recycling Process

Stage	Process	Recovery
Collection	Gathering from households, offices	Whole devices
Dismantling	Manual separation of components	Plastics, metals, circuit boards
Shredding	Mechanical size reduction	Mixed material streams
Separation	Magnetic, density, optical sorting	Ferrous, non-ferrous metals
Refining	Chemical processing	Pure metals (Au, Ag, Cu, Pd)

Recycling Methods:

- **Mechanical**: Physical separation and size reduction
- **Pyrometallurgy**: High-temperature metal recovery
- **Hydrometallurgy**: Chemical leaching processes
- **Biotechnology**: Microbial metal extraction

Benefits:

- **Resource conservation**: Recovery of precious metals
- **Environmental protection**: Prevents soil and water contamination
- **Economic value**: Job creation and revenue generation
- **Energy savings**: Less energy than primary production

Mnemonic

"CDSPR" - Collection, Dismantling, Shredding, Separation, Refining

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Question 2(c OR) [07 marks]

Define pollution and its source. Explain the classification of pollutants.

Solution

Definition: Pollution is the introduction of harmful substances or energy into the environment, causing adverse changes to air, water, soil, or living organisms.

Table 10: Sources of Pollution

Source Type	Examples	Pollutants Released
Point Sources	Industrial chimneys, sewage outfalls	Specific location discharge
Non-point Sources	Agricultural runoff, urban stormwater	Diffuse area pollution
Mobile Sources	Vehicles, ships, aircraft	Exhaust emissions
Stationary Sources	Power plants, factories	Stack emissions

Classification of Pollutants:
1. By Nature:

Table 11: Pollutant Classification by Nature

Type	Characteristics	Examples
Biodegradable	Decompose naturally	Organic waste, sewage
Non-biodegradable	Persist in environment	Plastics, heavy metals
Slowly degradable	Decompose over years	Pesticides, radioactive materials

2. By Form:
- **Primary**: Directly emitted (SO , CO, particulates)
- **Secondary**: Formed by reactions (O , acid rain, smog)

3. By Source:
- **Natural**: Volcanic eruptions, forest fires
- **Anthropogenic**: Human activities, industrial processes

Diagram: Pollution Classification

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Pollutants] {-{-}{} B[By Nature]}
    A {-{-}{} C[By Form]}
    A {-{-}{} D[By Source]}
    B {-{-}{} E[Biodegradable]}
    B {-{-}{} F[Non{-}biodegradable]}
    C {-{-}{} G[Primary]}
    C {-{-}{} H[Secondary]}
    D {-{-}{} I[Natural]}
    D {-{-}{} J[Anthropogenic]}
{Highlighting}
{Shaded}
```

Effects of Pollution:
- **Environmental**: Ecosystem disruption, species extinction
- **Health**: Respiratory diseases, cancer, genetic disorders
- **Economic**: Healthcare costs, reduced productivity
- **Social**: Quality of life degradation

Mnemonic

"BNS-PFC" - Biodegradable, Non-biodegradable, Slowly degradable - Primary, Form, Classification

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Question 3(a) [03 marks]

State the working of solar cell.

Solution

Solar cell converts light energy directly into electrical energy through photovoltaic effect using semiconductor materials.

Table 12: Solar Cell Working Process

Step	Process	Result
Photon Absorption	Light hits semiconductor	Electron excitation

Electron-Hole Generation	Energy breaks bonds	Free charge carriers
Charge Separation	Built-in electric field	Electrons to n-side, holes to p-side
Current Collection	External circuit connection	Electrical current flow

- **p-n junction**: Creates internal electric field
- **Depletion region**: Area with charge separation
- **External load**: Completes electrical circuit

Mnemonic

"PECS" - Photon, Electron, Charge, Separation

Question 3(b) [04 marks]

Give the comparison between Horizontal Axis and Vertical Axis wind mills.

Solution

Table 13: HAWT vs VAWT Comparison

Parameter	Horizontal Axis (HAWT)	Vertical Axis (VAWT)
Blade Orientation	Horizontal rotation	Vertical rotation
Wind Direction	Must face wind	Accepts from any direction
Efficiency	Higher (35-45%)	Lower (20-35%)
Height	Tower mounted, high	Ground level installation
Maintenance	Difficult, high altitude	Easy, ground accessible
Noise	Moderate	Lower
Cost	Higher initial	Lower installation
Power Output	Higher for large scale	Suitable for small scale

Advantages: **HAWT**: Higher efficiency, proven technology, better power-to-weight ratio **VAWT**: Omnidirectional, easier maintenance, quieter operation, urban friendly
Applications: **HAWT**: Large wind farms, utility-scale power generation **VAWT**: Urban areas, small-scale applications, distributed generation

Mnemonic

"HEAVEN" - Height, Efficiency, Accessibility, Versatility, Economics, Noise

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Question 3(c) [07 marks]

Explain construction and working of Biogas plant with sketch.

Solution

Biogas plant produces methane-rich gas through anaerobic digestion of organic waste materials by methanogenic bacteria.
Diagram: Biogas Plant

```
                Gas Outlet
                    ↑
Feed Inlet → [Digester] → Slurry Outlet
                    ↓
               Gas Holder
                    ↑
```

```
Underground Chamber
```

Table 14: Biogas Plant Components

Component	Function	Material
Digester	Anaerobic fermentation chamber	Concrete/steel
Gas Holder	Gas storage and pressure regulation	Steel/plastic
Inlet Chamber	Feed material entry	Masonry
Outlet Chamber	Slurry discharge	Masonry
Mixing Tank	Raw material preparation	Concrete

Construction Details:
Underground Digester:

- **Shape**: Cylindrical or dome-shaped
- **Capacity**: 10-100 m^3 for household plants
- **Wall thickness**: 10-15 cm concrete
- **Insulation**: Prevents heat loss

Working Process:

Table 15: Biogas Production Stages

Stage	Process	Duration	Products
Hydrolysis	Large molecules breakdown	1-3 days	Simple sugars, amino acids
Acidogenesis	Acid formation	3-7 days	Organic acids, alcohols
Methanogenesis	Methane production	15-30 days	CH (60%), CO (40%)

Operating Conditions:

- **Temperature**: 30-40°C (mesophilic)
- **pH**: 6.8-7.2 (neutral)
- **C:N ratio**: 25-30:1 optimal
- **Retention time**: 20-30 days

Applications:

- **Cooking**: Clean burning fuel
- **Lighting**: Gas lamps
- **Heating**: Space and water heating
- **Electricity**: Generator sets

Advantages:

- **Renewable energy**: Sustainable fuel source
- **Waste management**: Organic waste disposal
- **Fertilizer production**: Nutrient-rich slurry
- **Environmental benefits**: Reduces greenhouse gases

Mnemonic

"BIGHM" - Biological, Input, Gas, Holder, Methane

Question 3(a OR) [03 marks]

List the advantages of flat plate collector.

Solution

Table 16: Flat Plate Collector Advantages

Category	Advantages
Technical	Simple design, no moving parts, low maintenance
Economic	Low cost, mass production possible

Operational	Works with diffuse light, handles both direct and indirect radiation
Durability	Long life (15-20 years), weather resistant
Versatility	Multiple applications, modular installation

Key Benefits:
- **Reliability**: No complex mechanisms or controls required
- **Efficiency**: 40-60% thermal efficiency in optimal conditions
- **Installation**: Easy mounting on roofs or ground

Mnemonic

"TEODV" - Technical, Economic, Operational, Durability, Versatility

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Question 3(b OR) [04 marks]

What is wind farm? List its advantages.

Solution

Definition: Wind farm is a group of wind turbines installed in the same location for commercial electricity generation, connected to electrical grid through transmission lines.

Table 17: Wind Farm Advantages

Category	Advantages
Environmental	Clean energy, zero emissions, reduces carbon footprint
Economic	Job creation, low operating costs, revenue for landowners
Technical	Scalable capacity, grid stability, energy independence
Social	Rural development, community benefits, educational opportunities

Specific Benefits:
- **Land use efficiency**: Farming can continue between turbines
- **Quick installation**: Faster than conventional power plants
- **Predictable costs**: Fixed fuel cost (wind is free)
- **Modular expansion**: Capacity can be increased incrementally

Applications:
- **Onshore**: Land-based installations
- **Offshore**: Ocean-based for higher wind speeds
- **Distributed**: Small-scale community projects

Mnemonic

"ECTS" - Environmental, Economic, Technical, Social benefits

Question 3(c OR) [07 marks]

Explain in brief (1) Geothermal energy (2) Tidal energy

Solution

(1) Geothermal Energy:
Geothermal energy harnesses heat from Earth's interior for electricity generation and direct heating applications.

Table 18: Geothermal Energy Systems

Type	Temperature	Applications
High Temperature	>150°C	Electricity generation
Medium Temperature	90-150°C	Direct heating, cooling
Low Temperature	<90°C	Heat pumps, agriculture

Working Principle:

- **Heat source**: Radioactive decay in Earth's core
- **Extraction**: Wells drilled to access hot water/steam
- **Conversion**: Steam drives turbines for electricity
- **Reinjection**: Water returned to reservoir

(2) Tidal Energy:

Tidal energy converts kinetic and potential energy of ocean tides into electricity using predictable tidal movements.

Table 19: Tidal Energy Technologies

Technology	Principle	Installation
Tidal Barrage	Potential energy of tidal range	Dam across estuary
Tidal Stream	Kinetic energy of tidal currents	Underwater turbines
Tidal Lagoon	Artificial impoundment	Breakwater construction

Advantages: Geothermal: Baseload power, low emissions, small footprint, reliable **Tidal**: Predictable, high energy density, long lifespan, no fuel costs

Challenges: Geothermal: Location specific, high initial cost, induced seismicity **Tidal**: High capital cost, environmental impact, limited locations

Mnemonic

"GT-POWER" - Geothermal Temperature, Tidal Predictable Ocean Water Energy Resource

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Question 4(a) [03 marks]

Explain Need of Renewable energy.

Solution

Table 20: Need for Renewable Energy

Driver	Reasons
Environmental	Climate change mitigation, reduced pollution
Economic	Energy security, price stability, job creation
Technical	Depleting fossil fuels, technological advancement
Social	Rural development, health benefits, energy access

Key Needs:

- **Climate commitments**: Meet Paris Agreement targets
- **Energy independence**: Reduce import dependence
- **Sustainable development**: Long-term energy security

Mnemonic

"EETS" - Environmental, Economic, Technical, Social needs

Question 4(b) [04 marks]

Explain Depletion of ozone layer.

Solution

Ozone layer depletion is the reduction of ozone concentration in stratosphere due to human-made chemicals, particularly chlorofluorocarbons (CFCs).

Table 21: Ozone Depletion Process

Stage	Process	Chemical Reaction
CFC Release	Industrial emissions	CFCs rise to stratosphere
UV Breakdown	Photodissociation	CFC + UV $\rightarrow$ Cl + other products
Ozone Destruction	Catalytic cycle	Cl + O $\rightarrow$ ClO + O
Chain Reaction	Continuous process	ClO + O $\rightarrow$ Cl + O

Causes:
- **Primary**: CFCs, halons, methyl bromide
- **Secondary**: HCFCs, nitrous oxide, carbon tetrachloride

Effects:
- **Increased UV-B radiation**: Skin cancer, cataracts
- **Environmental impact**: Reduced crop yields, marine ecosystem damage
- **Climate effects**: Altered atmospheric circulation

Solutions:
- **Montreal Protocol**: International agreement (1987)
- **CFC phase-out**: Replacement with ozone-friendly alternatives
- **HCFC transition**: Temporary substitutes being phased out

Mnemonic

"CURE" - CFCs, UV, Reactions, Effects

Question 4(c) [07 marks]

Explain: (1) Greenhouse effect (2) climate change management

Solution

(1) Greenhouse Effect:
Natural process where certain atmospheric gases trap heat from sun, maintaining Earth's temperature suitable for life.

Diagram: Greenhouse Effect

```
flowchart LR
    A[Solar Radiation] {-{-} B[Earths Surface]}
    B {-{-} C[Heat Radiation]}
    C {-{-} D[Greenhouse Gases]}
    D {-{-} E[Heat Trapped]}
    E {-{-} F[Re{-}radiated to Earth]}
    F {-{-} B}
```

Table 22: Greenhouse Gases

Gas	Sources	Contribution	Lifetime
CO	Fossil fuels, deforestation	76%	300-1000 years
CH	Agriculture, landfills	16%	12 years
N O	Fertilizers, combustion	6%	120 years
F-gases	Industrial processes	2%	Varies

Enhanced Greenhouse Effect:

- **Cause**: Increased GHG concentrations from human activities
- **Result**: Global temperature rise, climate change
- **Feedback loops**: Amplify warming effects

(2) Climate Change Management:

Comprehensive approach to address climate change through mitigation and adaptation strategies.

Table 23: Climate Change Management Strategies

Strategy	Approach	Examples
Mitigation	Reduce GHG emissions	Renewable energy, energy efficiency
Adaptation	Adjust to climate impacts	Sea walls, drought-resistant crops
Technology	Innovation solutions	Carbon capture, smart grids
Policy	Regulatory frameworks	Carbon pricing, emissions standards
International	Global cooperation	Paris Agreement, climate finance

Mitigation Measures:

- **Energy sector**: Renewable energy deployment, efficiency improvements
- **Transport**: Electric vehicles, public transport, biofuels
- **Industry**: Process optimization, low-carbon technologies
- **Buildings**: Green construction, smart systems
- **Agriculture**: Sustainable practices, reduced emissions

Adaptation Measures:

- **Infrastructure**: Climate-resilient design, flood protection
- **Ecosystem**: Conservation, restoration, corridors
- **Water resources**: Efficient use, storage, quality management
- **Health**: Disease surveillance, heat wave preparedness

Management Framework:

1. **Assessment**: Climate risk and vulnerability analysis
2. **Planning**: Integrated strategies and action plans
3. **Implementation**: Project execution and monitoring
4. **Evaluation**: Performance assessment and adjustment

Mnemonic

"GEMMA" - Gases, Enhanced, Mitigation, Management, Adaptation

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Question 4(a OR) [03 marks]

Discuss Factors affecting climate change.

Solution

Table 24: Climate Change Factors

Factor Type	Examples	Impact
Natural	Solar variations, volcanic eruptions	Minor influence
Anthropogenic	GHG emissions, land use change	Major driver
Feedback	Ice-albedo, water vapor	Amplification

Key Factors:

- **Greenhouse gas concentrations**: Primary driver of warming
- **Aerosols**: Cooling effect, masks some warming
- **Land use changes**: Deforestation, urbanization effects

Mnemonic

"NAF" - Natural, Anthropogenic, Feedback factors

Question 4(b OR) [04 marks]

Explain climate change.

Solution

Climate change refers to long-term shifts in global temperatures and weather patterns, primarily caused by human activities since mid-20th century.

Table 25: Climate Change Indicators

Indicator	Observed Changes	Trend
Temperature	+1.1°C since 1880	Rising
Sea Level	21-24 cm since 1880	Rising
Arctic Ice	13% per decade loss	Declining
Precipitation	Regional variations	Changing patterns

Causes:
- **Primary**: Greenhouse gas emissions from fossil fuels
- **Secondary**: Deforestation, industrial processes, agriculture

Impacts:
- **Physical**: Extreme weather, sea level rise, ice loss
- **Biological**: Species migration, ecosystem disruption
- **Human**: Food security, water resources, health

Evidence:
- **Temperature records**: Global warming trend
- **Ice core data**: Historical CO levels
- **Satellite observations**: Ice sheet changes

Mnemonic

"CHIP" - Causes, Human impacts, Indicators, Physical evidence

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Question 4(c OR) [07 marks]

Write short note on Global warming.

Solution

Global warming is the long-term increase in Earth's average surface temperature due to enhanced greenhouse effect from human activities.

Table 26: Global Warming Components

Aspect	Details	Impact
Definition	Increase in global average temperature	+1.1°C since pre-industrial
Primary Cause	CO emissions from fossil fuels	410+ ppm atmospheric CO
Timeline	Accelerated since 1950s	Fastest warming in 10,000 years
Regional Variation	Arctic warming 2x global average	Polar amplification

Causes of Global Warming:

Table 27: Emission Sources

Sector	Contribution	Main Activities
Energy	73%	Electricity, heat, transport
Agriculture	18%	Livestock, rice cultivation
Industrial	5%	Cement, steel, chemicals
Waste	3%	Landfills, wastewater
Land Use	1%	Deforestation, development

Consequences:

- **Physical impacts**: Sea level rise, glacier retreat, permafrost thaw
- **Weather patterns**: More frequent heatwaves, altered precipitation
- **Ecosystem effects**: Species extinction, habitat loss, coral bleaching
- **Human impacts**: Agricultural disruption, water scarcity, health risks

Feedback Mechanisms:

- **Ice-albedo feedback**: Less ice → more heat absorption
- **Water vapor feedback**: Warmer air holds more moisture
- **Permafrost feedback**: Thawing releases stored carbon

Solutions:

- **Mitigation**: Reduce greenhouse gas emissions
- **Renewable energy**: Solar, wind, hydroelectric power
- **Energy efficiency**: Buildings, transport, industry
- **Carbon sequestration**: Forests, soil, technological capture
- **Policy measures**: Carbon pricing, regulations, incentives

International Response:

- **UNFCCC**: Framework Convention on Climate Change
- **Kyoto Protocol**: First binding emission reduction agreement
- **Paris Agreement**: Current global climate accord (2015)
- **IPCC Reports**: Scientific assessment and guidance

Future Projections:

- **Temperature rise**: 1.5-4.5°C by 2100 depending on emissions
- **Sea level rise**: 0.43-2.84 m by 2100
- **Tipping points**: Irreversible changes in climate system

Mnemonic

"GWCF" - Global Warming Causes Consequences Feedback

Question 5(a) [03 marks]

Explain the concept of "Eco Tourism"

Solution

Eco-tourism is responsible travel to natural areas that conserves environment, sustains well-being of local people, and involves interpretation and education.

Table 28: Eco-tourism Principles

Principle	Description
Conservation	Protect natural habitats and wildlife
Community	Benefit local communities economically
Education	Environmental awareness and learning
Sustainability	Long-term environmental protection
Responsibility	Minimize negative impacts

- **Nature-based**: Focus on natural environments
- **Low-impact**: Minimal environmental disturbance
- **Cultural respect**: Value local traditions and customs

Mnemonic

"ECERS" - Environment, Community, Education, Responsibility, Sustainability

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Question 5(b) [04 marks]

Comparison of conventional and nonconventional energy source.

Solution

Table 29: Conventional vs Non-conventional Energy Sources

Parameter	Conventional	Non-conventional
Examples	Coal, oil, natural gas, nuclear	Solar, wind, hydro, biomass
Availability	Limited reserves	Abundant and renewable
Environmental Impact	High pollution, CO emissions	Clean, minimal emissions
Cost	Initially lower, rising prices	High initial, decreasing costs
Technology	Mature, established	Developing, improving
Reliability	Consistent supply	Weather dependent
Infrastructure	Well-established	Requires development
Depletion	Exhaustible resources	Inexhaustible sources

Advantages: **Conventional**: Reliable supply, established infrastructure, high energy density **Non-conventional**: Sustainable, clean, job creation, energy independence
Challenges: **Conventional**: Environmental damage, price volatility, finite resources **Non-conventional**: Intermittency, storage needs, initial investment

Mnemonic

"CATERED" - Conventional Available Technology Established Reliable Environmental Depletion

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Question 5(c) [07 marks]

Explain (1) The water Act, 1974 (2) The Environment Act, 1986

Solution

(1) The Water (Prevention and Control of Pollution) Act, 1974:
Comprehensive legislation to prevent and control water pollution and maintain/restore wholesomeness of water in India.

Table 30: Water Act 1974 - Key Provisions

Aspect	Details
Objective	Prevent and control water pollution
Authority	Central and State Pollution Control Boards
Coverage	All water bodies - rivers, streams, wells, groundwater
Penalties	Fines and imprisonment for violations

Key Features:

- **Pollution Control Boards**: Establishment at central and state levels
- **Consent mechanism**: No-objection certificates for industries
- **Standards**: Water quality standards and effluent discharge limits
- **Monitoring**: Regular inspection and sampling of water bodies
- **Emergency provisions**: Power to handle pollution emergencies

Powers of Boards:

- **Planning**: Pollution prevention and control programs
- **Standard setting**: Water quality and discharge standards
- **Consent granting**: Permission for waste discharge
- **Monitoring**: Water quality surveillance
- **Enforcement**: Legal action against violators

(2) The Environment (Protection) Act, 1986:

Umbrella legislation providing framework for environmental protection and improvement in India, enacted after Bhopal gas tragedy.

Table 31: Environment Act 1986 - Key Provisions

Aspect	Details
Objective	Comprehensive environmental protection
Scope	Air, water, land pollution and hazardous substances
Authority	Central Government and designated agencies
Penalties	Imprisonment up to 5 years and/or fine up to 1 lakh

Key Features:

- **General powers**: Central government authority for environmental protection
- **Standards**: Environmental quality standards for air, water, soil
- **Impact assessment**: Environmental clearance for projects
- **Hazardous substances**: Regulation of handling and disposal
- **Public participation**: Right to information and participation

Important Rules:

- **EIA Notification 2006**: Environmental Impact Assessment
- **Hazardous Waste Rules**: Management and handling
- **Noise Pollution Rules**: Ambient noise standards
- **Coastal Regulation Zone**: Coastal area protection

Comparison:

Table 32: Water Act vs Environment Act

Aspect	Water Act 1974	Environment Act 1986
Scope	Water pollution only	All environmental media
Approach	Sectoral	Comprehensive
Implementation	PCBs	Central Government
Penalties	Moderate	Stringent

Enforcement Mechanisms:

- **Monitoring**: Regular inspection and compliance checking
- **Legal action**: Prosecution of violators
- **Closure orders**: Shutting down polluting units
- **Compensation**: Environmental damage assessment

Mnemonic

"WEPCA" - Water Environmental Protection Comprehensive Act

Question 5(a OR) [03 marks]

Explain the concept "Carbon Credit"

Solution

Carbon credit is a tradeable certificate representing one tonne of CO equivalent reduced or removed from atmosphere through emission reduction or carbon sequestration projects.

Table 33: Carbon Credit Mechanism

Component	Description
Unit	1 credit = 1 tonne CO equivalent
Generation	Emission reduction/removal projects
Trading	Buy/sell in carbon markets
Verification	Third-party validation required

- **CDM**: Clean Development Mechanism under Kyoto Protocol
- **Voluntary markets**: Private sector initiatives
- **Compliance markets**: Regulatory requirements

Mnemonic

"CUTV" - Credit Unit Trading Verification

Question 5(b OR) [04 marks]

Explain in brief "Solid waste Management"

Solution

Solid waste management is systematic collection, transport, processing, recycling, and disposal of solid materials discarded by human activities.

Table 34: Solid Waste Management Hierarchy

Priority	Method	Description
1st	**Reduce**	Minimize waste generation
2nd	**Reuse**	Use items multiple times
3rd	**Recycle**	Convert waste to new products
4th	**Recovery**	Energy recovery from waste
5th	**Disposal**	Safe landfilling

Management Process:

- **Collection**: Door-to-door pickup, segregation at source
- **Transportation**: Transfer stations, bulk transport
- **Treatment**: Composting, recycling, incineration
- **Disposal**: Sanitary landfills, waste-to-energy

Technologies:

- **Composting**: Organic waste decomposition
- **Incineration**: High-temperature burning with energy recovery
- **Anaerobic digestion**: Biogas production from organic waste
- **Material recovery**: Separation and recycling of materials

Challenges:

- **Increasing quantities**: Population and consumption growth
- **Mixed waste**: Lack of source segregation
- **Infrastructure**: Inadequate collection and treatment facilities
- **Financing**: High capital and operational costs

Mnemonic

"CTTD" - Collection, Transportation, Treatment, Disposal

Question 5(c OR) [07 marks]

Explain the concept of "5R"

Solution

The 5R concept is a comprehensive waste management hierarchy that promotes sustainable consumption and waste reduction through five interconnected strategies.

Table 35: 5R Waste Management Hierarchy

R	Strategy	Definition	Examples
1. Refuse	Reject unnecessary items	Avoid products that create waste	Say no to plastic bags, disposable items
2. Reduce	Minimize consumption	Use less of resources	Buy only needed items, choose durable products
3. Reuse	Use items multiple times	Extend product lifespan	Repurpose containers, donate old clothes
4. Repurpose	Creative alternative uses	Transform waste into useful items	Convert bottles to planters, tires to swings
5. Recycle	Process waste into new products	Material recovery and reprocessing	Paper, plastic, metal recycling

Detailed Explanation:

1. **Refuse:**
   - **Concept**: First line of defense against waste
   - **Implementation**: Consumer choice and awareness
   - **Impact**: Prevents waste generation at source
   - **Examples**: Refusing single-use plastics, unnecessary packaging
2. **Reduce:**
   - **Concept**: Minimize resource consumption and waste generation
   - **Strategies**: Efficient use, durability focus, sharing economy
   - **Benefits**: Lower environmental footprint, cost savings
   - **Applications**: Energy efficiency, water conservation, minimal packaging
3. **Reuse:**
   - **Concept**: Extend product life without reprocessing
   - **Methods**: Direct reuse, repair and maintenance, redistribution
   - **Advantages**: Energy savings, economic benefits, creativity
   - **Examples**: Glass jars for storage, furniture restoration
4. **Repurpose:**
   - **Concept**: Creative transformation for different functions
   - **Innovation**: Design thinking and creativity
   - **Community aspect**: Maker spaces, DIY culture
   - **Environmental benefit**: Waste diversion from landfills
5. **Recycle:**
   - **Concept**: Material recovery and reprocessing
   - **Types**: Mechanical, chemical, biological recycling
   - **Infrastructure**: Collection, sorting, processing facilities
   - **Markets**: End-use applications for recycled materials

Implementation Framework:

Table 36: 5R Implementation Levels

Level	Stakeholders	Actions	Outcomes
Individual	Consumers, households	Conscious choices, lifestyle changes	Reduced personal footprint
Community	Neighborhoods, schools	Local programs, awareness campaigns	Community engagement
Business	Companies, industries	Circular economy, sustainable design	Resource efficiency
Government	Policy makers, regulators	Regulations, incentives, infrastructure	System-wide change

Benefits of 5R Approach:

- **Environmental**: Reduced pollution, resource conservation, climate protection
- **Economic**: Cost savings, job creation, new business opportunities
- **Social**: Community engagement, education, behavioral change
- **Resource security**: Reduced dependence on virgin materials

Challenges:

- **Consumer behavior**: Changing established habits and preferences
- **Infrastructure**: Adequate collection and processing facilities
- **Economics**: Market viability of recycled products
- **Policy support**: Regulatory framework and incentives

Success Factors:

- **Education**: Awareness and capacity building programs
- **Infrastructure**: Adequate waste management systems
- **Policy**: Supportive regulations and economic instruments
- **Technology**: Innovation in waste processing and product design
- **Collaboration**: Multi-stakeholder partnerships

Circular Economy Connection: The 5R concept forms the foundation of circular economy principles, where waste becomes input for new production cycles, minimizing resource extraction and environmental impact.

Measurement and Monitoring:

- **Waste reduction metrics**: Quantity diverted from disposal
- **Material recovery rates**: Percentage of waste recycled/reused
- **Environmental indicators**: Carbon footprint, resource consumption
- **Economic metrics**: Cost savings, job creation, revenue generation

Global Examples:

- **Zero Waste Cities**: San Francisco, Ljubljana, Kamikatsu
- **Extended Producer Responsibility**: EU packaging regulations
- **Deposit Systems**: Bottle return programs in Germany, Canada
- **Sharing Economy**: Tool libraries, clothing swaps, repair cafes

Future Directions:

- **Digital platforms**: Apps for waste reduction and sharing
- **Advanced recycling**: Chemical recycling, AI-powered sorting
- **Bioplastics**: Biodegradable alternatives to conventional plastics
- **Policy evolution**: Right to repair, extended producer responsibility

Mnemonic

"R5-POWER" - Refuse, Reduce, Reuse, Repurpose, Recycle - Protect Our World's Environmental Resources