Environment and Sustainability Solutions

4300003 – Winter 2022

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

When ecological overshoot occurs? Explain with reasons.

Solution

Table 1: Ecological Overshoot Conditions

Condition	Description	Impact
Resource depletion	Consumption exceeds regeneration rate	Deficit accumulation
Population pressure	Human demand surpasses carrying capacity	Resource scarcity
Waste accumulation	Production exceeds absorption capacity	Environmental degradation

Ecological overshoot occurs when humanity's ecological footprint exceeds Earth's biocapacity. This happens when we consume resources faster than nature can regenerate them and produce waste faster than ecosystems can absorb it.

Key reasons include:

- **Population growth**: Increasing human numbers
- **Consumption patterns**: High per-capita resource use
- **Technology impact**: Inefficient resource utilization

Mnemonic

"POP-CON-TECH" (Population-Consumption-Technology)

Question 1(b) [4 marks]

Explain food chain using diagram.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Sun Energy] {-{-}{} B[Producer: Green Plants]}
    B {-{-}{} C[Primary Consumer: Herbivores]}
    C {-{-}{} D[Secondary Consumer: Carnivores]}
    D {-{-}{} E[Tertiary Consumer: Top Predators]}
    E {-{-}{} F[Decomposer: Bacteria/Fungi]}
    F {-{-}{} G[Nutrients to Soil]}
    G {-{-}{} B}
{Highlighting}
{Shaded}
```

Food chain represents the linear sequence of energy transfer from one trophic level to another in an ecosystem.

Components:

- **Producers**: Convert solar energy to chemical energy
- **Primary consumers**: Feed on producers (herbivores)
- **Secondary consumers**: Feed on primary consumers (carnivores)
- **Decomposers**: Break down dead organisms

Energy flow: Unidirectional from sun to top predators with 10% efficiency between levels.

Mnemonic

"PPSD" (Producer-Primary-Secondary-Decomposer)

Question 1(c) [7 marks]

Write a note on: carbon cycle.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Atmospheric CO2] {-{-}{} B[Photosynthesis]}
    B {-{-}{} C[Plant Biomass]}
    C {-{-}{} D[Animal Consumption]}
    D {-{-}{} E[Respiration]}
    E {-{-}{} A}
    C {-{-}{} F[Decomposition]}
    F {-{-}{} A}
    A {-{-}{} G[Ocean Dissolution]}
    G {-{-}{} H[Marine Life]}
    H {-{-}{} A}
    I[Fossil Fuel Burning] {-{-}{} A}
{Highlighting}
{Shaded}
```

Carbon cycle is the biogeochemical process where carbon moves through atmosphere, biosphere, hydrosphere, and geosphere.

Major processes:

- **Photosynthesis**: Plants absorb CO2 from atmosphere
- **Respiration**: Organisms release CO2 back to atmosphere
- **Decomposition**: Dead organic matter releases stored carbon
- **Ocean exchange**: CO2 dissolves in seawater forming carbonic acid

Human impact:

- **Fossil fuel combustion**: Increases atmospheric CO2
- **Deforestation**: Reduces carbon sequestration capacity
- **Industrial processes**: Additional carbon emissions

Environmental significance: Maintains atmospheric CO2 balance, regulates global temperature, supports life processes.

Mnemonic

"PRDO-FDI" (Photosynthesis-Respiration-Decomposition-Ocean, Fossil-Deforestation-Industry)

Question 1(c) OR [7 marks]

Classify aquatic ecosystem. Explain marine ecosystem.

Solution

Table 3: Aquatic Ecosystem Classification

Type	Characteristics	Examples
Freshwater	Low salt content (<1%)	Rivers, lakes, ponds
Marine	High salt content (3.5%)	Oceans, seas

Brackish Mixed fresh-salt water Estuaries, lagoons

Marine Ecosystem Components:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Marine Ecosystem] {-{-}{} B[Pelagic Zone]}
    A {-{-}{} C[Benthic Zone]}
    B {-{-}{} D[Photic Zone: 0{-}200m]}
    B {-{-}{} E[Aphotic Zone: {}200m]}
    C {-{-}{} F[Continental Shelf]}
    C {-{-}{} G[Deep Ocean Floor]}
{Highlighting}
{Shaded}
```

Marine ecosystem covers 71% of Earth's surface, containing saltwater bodies with complex food webs.
Zones:

- **Pelagic**: Open water column with plankton, fish
- **Benthic**: Ocean floor with bottom-dwelling organisms
- **Intertidal**: Shore area between high and low tides

Importance:

- **Climate regulation**: Ocean currents moderate global temperature
- **Oxygen production**: Marine phytoplankton produce 50% of atmospheric oxygen
- **Economic value**: Fisheries, transportation, tourism

Mnemonic

"PBI-COE" (Pelagic-Benthic-Intertidal, Climate-Oxygen-Economy)

Question 2(a) [3 marks]

What is carrying capacity of earth?

Solution

Table 5: Carrying Capacity Factors

Factor	Description	Limit
Resources	Available land, water, minerals	Finite
Food production	Agricultural capacity	Limited by soil
Waste absorption	Ecosystem's waste processing	Saturation point

Carrying capacity is the maximum population size an environment can sustain indefinitely without degrading the environment.
Earth's carrying capacity depends on:

- **Resource availability**: Fresh water, arable land, energy sources
- **Technology level**: Efficiency of resource utilization
- **Consumption patterns**: Per-capita resource demand

Current estimates: Range from 4-16 billion people based on consumption levels and technological advancement.

Mnemonic

"RTC" (Resources-Technology-Consumption)

Question 2(b) [4 marks]

How food web relates to food chain?

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Grass] {-{-}{} B[Rabbit]}
    A {-{-}{} C[Deer]}
    B {-{-}{} D[Fox]}
    C {-{-}{} D}
    B {-{-}{} E[Hawk]}
    C {-{-}{} F[Wolf]}
    D {-{-}{} G[Decomposers]}
    E {-{-}{} G}
    F {-{-}{} G}
{Highlighting}
{Shaded}
```

Food web is an interconnected network of multiple food chains showing complex feeding relationships in an ecosystem.

Relationship between food web and food chain:

- **Food chain**: Linear sequence of energy transfer
- **Food web**: Multiple interconnected food chains
- **Complexity**: Food webs show realistic ecosystem interactions
- **Stability**: Multiple pathways provide ecosystem resilience

Key differences:

- **Structure**: Chain is linear, web is network-based
- **Energy flow**: Chain shows single pathway, web shows multiple routes
- **Species interaction**: Web demonstrates omnivory and alternative feeding

Mnemonic

"LNCR" (Linear-Network, Chain-Resilience)

Question 2(c) [7 marks]

Write a note on: air pollution

Solution

Table 7: Air Pollution Sources and Effects

Pollutant	Source	Health Effect
PM2.5/PM10	Vehicles, industries	Respiratory diseases
SO2	Coal burning	Acid rain, asthma
NOx	Vehicle exhaust	Smog formation
CO	Incomplete combustion	Oxygen deficiency

Air pollution is contamination of atmosphere by harmful substances that cause adverse effects on human health and environment.
Classification by source:
- **Primary pollutants**: Directly emitted (CO, SO2, particulates)
- **Secondary pollutants**: Formed through chemical reactions (ozone, acid rain)

Major sources:
- **Mobile sources**: Vehicles, aircraft, ships
- **Stationary sources**: Power plants, industries, residential heating
- **Natural sources**: Volcanic eruptions, forest fires, dust storms

Control measures:
- **Technological**: Catalytic converters, scrubbers, filters
- **Regulatory**: Emission standards, fuel quality norms
- **Alternative energy**: Renewable sources, electric vehicles

Health impacts: Respiratory diseases, cardiovascular problems, cancer, reduced life expectancy.
Environmental effects: Acid rain, ozone depletion, climate change, visibility reduction.

Mnemonic

"PSMT-RE-HE" (Primary-Secondary-Mobile-stationary-Technological-Regulatory-Health-Environment)

Question 2(a) OR [3 marks]

Explain bad effects of plastic waste on environment.

Solution

Table 9: Plastic Waste Environmental Effects

Impact Area	Effect	Duration
Marine life	Entanglement, ingestion	Persistent
Soil	Microplastic contamination	500+ years
Food chain	Bioaccumulation	Generational

Plastic waste causes severe environmental degradation due to its non-biodegradable nature.
Environmental effects:
- **Marine pollution**: Ocean plastic kills marine animals through entanglement and ingestion
- **Soil contamination**: Microplastics affect soil fertility and crop growth
- **Food chain disruption**: Plastic particles accumulate in organisms

Long-term impacts: Persistent organic pollutants, habitat destruction, ecosystem imbalance.

Mnemonic

"MSF" (Marine-Soil-Foodchain)

Question 2(b) OR [4 marks]

Which are signs of polluted water? List major sources of water pollution.

Solution

Table 11: Water Pollution Indicators and Sources

Signs	Measurement	Sources
High BOD/COD	>5 mg/L	Industrial discharge
Turbidity	Cloudiness	Agricultural runoff
pH changes	<6.5 or >8.5	Acid mine drainage
Foul odor	H2S smell	Sewage discharge

Signs of polluted water:
- **Physical**: Color change, turbidity, floating debris, odor
- **Chemical**: High BOD/COD, pH deviation, heavy metals, toxic compounds
- **Biological**: Pathogenic microorganisms, algal blooms, fish kills

Major sources:
- **Point sources**: Industrial discharge, sewage outfalls, concentrated animal feeding
- **Non-point sources**: Agricultural runoff, urban stormwater, atmospheric deposition

Mnemonic

"PCB-PIN" (Physical-Chemical-Biological, Point-Non-point)

Question 2(c) OR [7 marks]

Classify e-waste. How e-waste is recycled?

Solution

Table 13: E-waste Classification

Category	Examples	Hazardous Components
Large appliances	Refrigerators, washing machines	CFCs, heavy metals
Small appliances	Microwaves, vacuum cleaners	Plastics, metals
IT equipment	Computers, printers	Lead, mercury, cadmium
Consumer electronics	TVs, mobile phones	Rare earth elements

E-waste classification:
- **White goods**: Large household appliances
- **Brown goods**: Entertainment electronics
- **Gray goods**: IT and telecommunication equipment
- **Green goods**: Renewable energy equipment

E-waste recycling process:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Collection] {-{-}{} B[Sorting]}
    B {-{-}{} C[Dismantling]}
    C {-{-}{} D[Shredding]}
    D {-{-}{} E[Separation]}
    E {-{-}{} F[Material Recovery]}
    F {-{-}{} G[Refining]}
    G {-{-}{} H[New Products]}
{Highlighting}
{Shaded}
```

Recycling methods:
- **Mechanical**: Physical separation of materials
- **Metallurgical**: High-temperature processing for metal recovery
- **Chemical**: Leaching processes for precious metals

Challenges: Hazardous material handling, complex composition, economic viability.
Benefits: Resource conservation, pollution prevention, job creation, reduced mining needs.

Mnemonic

"WBGG-CSDSMR" (White-Brown-Gray-Green, Collection-Sorting-Dismantling-Shredding-Separation-Material-Refining)

Question 3(a) [3 marks]

Distinguish BOD and COD.

Solution

Table 15: BOD vs COD Comparison

Parameter	BOD	COD
Full form	Biochemical Oxygen Demand	Chemical Oxygen Demand
Test duration	5 days	2-3 hours
Oxidation type	Biological	Chemical
Degradation	Biodegradable organics only	All organic compounds

BOD (Biochemical Oxygen Demand):
- Measures oxygen consumed by microorganisms
- Indicates biodegradable organic pollution
- Standard test: 5 days at 20

COD (Chemical Oxygen Demand):
- Measures oxygen required for chemical oxidation
- Indicates total organic pollution
- Uses strong oxidizing agents (potassium dichromate)

Mnemonic

"BTCD" (Biological-Time-Chemical-Degradation)

Question 3(b) [4 marks]

Classify solid waste.

Solution

Table 17: Solid Waste Classification

Classification	Type	Examples
By source	Municipal, Industrial, Agricultural	Household, Factory, Farm waste
By composition	Organic, Inorganic	Food waste, Plastics
By hazard	Hazardous, Non-hazardous	Medical, Paper

Solid waste classification:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Solid Waste] {-{-}{} B[Municipal Solid Waste]}
    A {-{-}{} C[Industrial Waste]}
    A {-{-}{} D[Hazardous Waste]}
    A {-{-}{} E[Agricultural Waste]}
    B {-{-}{} F[Organic: 50{-}60\%]}
    B {-{-}{} G[Recyclables: 20{-}30\%]}
    B {-{-}{} H[Inert: 10{-}20\%]}
{Highlighting}
{Shaded}
```

By source:

- **Municipal**: Residential, commercial, institutional waste
- **Industrial**: Manufacturing, processing byproducts
- **Agricultural**: Crop residues, animal waste

By composition: Organic (biodegradable), inorganic (non-biodegradable), recyclable materials.
Management hierarchy: Reduce, reuse, recycle, recover, dispose.

Mnemonic

"MIA-OIR" (Municipal-Industrial-Agricultural, Organic-Inorganic-Recyclable)

Question 3(c) [7 marks]

With the use of diagram explain solar photovoltaic System.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Solar Radiation] {-{-}{} B[PV Panel]}
    B {-{-}{} C[DC Power]}
    C {-{-}{} D[Inverter]}
    D {-{-}{} E[AC Power]}
    E {-{-}{} F[Load/Grid]}
    G[Battery] {-{-}{} C}
    E {-{-}{} G}
    H[Charge Controller] {-{-}{} G}
    C {-{-}{} H}
{Highlighting}
{Shaded}
```

Solar Photovoltaic System converts sunlight directly into electricity using semiconductor materials.
Components:

- **PV modules**: Silicon cells convert light to DC electricity
- **Inverter**: Converts DC to AC power
- **Battery storage**: Stores excess energy for later use
- **Charge controller**: Regulates battery charging
- **Monitoring system**: Tracks performance and faults

Working principle:

1. **Photovoltaic effect**: Solar cells absorb photons
2. **Electron excitation**: Creates electron-hole pairs
3. **Current generation**: Electrons flow creating DC current

4. **Power conditioning**: Inverter converts DC to AC

Types:

- **Grid-connected**: Synchronized with utility grid
- **Stand-alone**: Independent systems with battery backup
- **Hybrid**: Combination of grid-connected and battery storage

Applications: Residential rooftops, commercial buildings, utility-scale power plants, remote area electrification.

Advantages: Clean energy, low maintenance, modular design, long lifespan (25+ years).

Mnemonic

"PIBCM-PECG" (Panel-Inverter-Battery-Controller-Monitor, Photovoltaic-Electron-Current-Grid)

Question 3(a) OR [3 marks]

Compare conventional and non-conventional energy sources.

Solution

Table 19: Energy Sources Comparison

Aspect	Conventional	Non-conventional
Availability	Limited reserves	Unlimited/renewable
Environmental impact	High pollution	Clean/minimal impact
Cost	Initially lower	Decreasing rapidly

Conventional energy sources: Coal, oil, natural gas, nuclear power - finite resources with environmental concerns.

Non-conventional energy sources: Solar, wind, hydro, biomass - renewable resources with sustainable characteristics.

Key differences: Depletion vs renewable, pollution vs clean, established vs emerging technology.

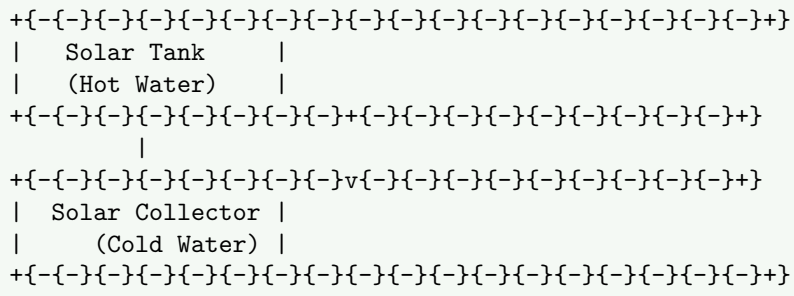
Mnemonic

"AEC" (Availability-Environmental-Cost)

Question 3(b) OR [4 marks]

Explain working of natural circulation solar water heater.

Solution



Natural circulation solar water heater uses thermosiphon principle for water circulation without external pumps.

Working principle:

- **Solar collection**: Collector absorbs solar radiation, heating water
- **Density difference**: Hot water becomes less dense, rises naturally
- **Circulation**: Cold water from tank bottom flows to collector
- **Storage**: Hot water accumulates in insulated storage tank

Components: Flat plate collector, insulated storage tank, connecting pipes, safety valves.

Advantages: No electricity required, simple design, low maintenance, cost-effective.

Mnemonic

"SDCS" (Solar-Density-Circulation-Storage)

Question 3(c) OR [7 marks]

Explain working principle of horizontal axis wind turbine.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Wind Energy] {-{-}{} B[Rotor Blades]}
    B {-{-}{} C[Shaft Rotation]}
    C {-{-}{} D[Gearbox]}
    D {-{-}{} E[Generator]}
    E {-{-}{} F[Electrical Power]}
    G[Nacelle] {-{-}{} B}
    H[Tower] {-{-}{} G}
{Highlighting}
{Shaded}
```

Horizontal Axis Wind Turbine (HAWT) converts kinetic energy of wind into electrical energy using aerodynamic lift principle.

Working principle:

1. **Wind capture**: Rotor blades designed with aerodynamic profile
2. **Lift generation**: Pressure difference across blade surfaces creates lift force
3. **Rotation**: Lift force causes rotor to rotate around horizontal axis
4. **Speed conversion**: Gearbox increases rotational speed from 30-50 rpm to 1500 rpm
5. **Power generation**: High-speed rotation drives electrical generator

Components:

- **Rotor assembly**: 2-3 blades, hub, pitch control system
- **Nacelle**: Houses gearbox, generator, control systems
- **Tower**: Supports nacelle at optimal height (50-120m)
- **Foundation**: Concrete base for structural stability

Control systems:

- **Yaw system**: Orients turbine to face wind direction
- **Pitch control**: Adjusts blade angle for optimal wind capture
- **Brake system**: Emergency stopping mechanism

Advantages: High efficiency (35-45%), proven technology, economies of scale. **Disadvantages**: Visual impact, noise, bird strikes, wind variability.

Power calculation: $P = 0.5 \times \times A \times V^3 \times CpWhere: = airdensity$,
A = swept area,
V = wind speed, Cp = power coefficient

Mnemonic

"WLRSG-RNTP-YPB" (Wind-Lift-Rotation-Speed-Generation, Rotor-Nacelle-Tower-Foundation, Yaw-Pitch-Brake)

Question 4(a) [3 marks]

Write advantages and disadvantages of tidal energy.

Solution

Table 21: Tidal Energy Pros and Cons

Advantages	Disadvantages
Predictable energy source	Limited suitable locations
No greenhouse gas emissions	High initial capital cost
Long lifespan (100+ years)	Environmental impact on marine life

Tidal energy harnesses gravitational forces between Earth, moon, and sun to generate electricity.
Advantages:

- **Reliability**: Highly predictable tidal cycles
- **Clean energy**: Zero operational emissions
- **Durability**: Infrastructure lasts decades

Disadvantages:

- **Geographic limitations**: Requires specific coastal conditions
- **High costs**: Expensive installation and maintenance
- **Ecological impact**: Affects marine ecosystems

Mnemonic

"RCD-GHE" (Reliable-Clean-Durable, Geographic-High cost-Ecological)

Question 4(b) [4 marks]

Explain working principle of biogas plant.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Organic Waste Input] {-{-}{} B[Mixing Tank]}
    B {-{-}{} C[Digester Tank]}
    C {-{-}{} D[Gas Collection]}
    C {-{-}{} E[Slurry Output]}
    D {-{-}{} F[Biogas Storage]}
    F {-{-}{} G[End Use]}
{Highlighting}
{Shaded}
```

Biogas plant produces methane-rich gas through anaerobic digestion of organic waste materials.
Working principle:

1. **Feed preparation**: Organic waste mixed with water (1:1 ratio)
2. **Anaerobic digestion**: Bacteria break down organic matter in oxygen-free environment
3. **Gas production**: Methane (50-70%) and CO2 (30-40%) generated
4. **Gas collection**: Biogas collected in gas holder dome

Process stages:

- **Hydrolysis**: Complex organics broken into simple compounds
- **Acidogenesis**: Organic acids formation
- **Methanogenesis**: Methane production by methanogenic bacteria

Optimal conditions: Temperature 35-40$^{\circ}pH6.8 - 7.2, retentiontime15 - 30days$.

Mnemonic

"FAGH-HAM" (Feed-Anaerobic-Gas-Holder, Hydrolysis-Acidogenesis-Methanogenesis)

Question 4(c) [7 marks]

Explain green house effect.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Solar Radiation] {-{-}{} B[Earth{}s Surface]}
    B {-{-}{} C[Heat Absorption]}
    C {-{-}{} D[Infrared Radiation]}
    D {-{-}{} E[Greenhouse Gases]}
    E {-{-}{} F[Heat Trapping]}
    F {-{-}{} G[Re{-}radiation to Earth]}
    G {-{-}{} H[Global Warming]}
{Highlighting}
{Shaded}
```

Greenhouse effect is the process where atmospheric gases trap heat from sun, warming Earth's surface beyond normal temperature.

Natural greenhouse effect:

- **Solar radiation**: Sun emits short-wave radiation (visible light)
- **Surface absorption**: Earth absorbs solar energy, heats up
- **Heat re-emission**: Earth emits long-wave infrared radiation
- **Gas absorption**: Greenhouse gases absorb infrared radiation
- **Heat retention**: Trapped heat warms lower atmosphere

Greenhouse gases and contributions:

- **Carbon dioxide (CO2)**: 76% - fossil fuel burning, deforestation
- **Methane (CH4)**: 16% - agriculture, landfills, livestock
- **Nitrous oxide (N2O)**: 6% - fertilizers, fossil fuel combustion
- **Fluorinated gases**: 2% - industrial processes, refrigeration

Enhanced greenhouse effect: Human activities increase greenhouse gas concentrations, intensifying heat trapping.

Consequences:

- **Global temperature rise**: Average $1.1^{i}ncreasesincepre - industrialtimes$
- **Climate change**: Altered precipitation patterns, extreme weather events
- **Sea level rise**: Thermal expansion and ice sheet melting
- **Ecosystem disruption**: Species migration, coral bleaching, forest fires

Mitigation strategies:

- **Renewable energy**: Reduce fossil fuel dependence
- **Energy efficiency**: Improve technology and practices
- **Carbon sequestration**: Forest restoration, carbon capture storage
- **International cooperation**: Paris Agreement, emission reduction targets

Mnemonic

"SSAHR-CMNO-GTSE-RECC" (Solar-Surface-Absorption-Heat-Radiation, CO2-Methane-Nitrous-Other, Global-Temperature-Sea-Ecosystem, Renewable-Efficiency-Carbon-Cooperation)

Question 4(a) OR [3 marks]

What is climate change?

Solution

Table 23: Climate Change Indicators

Indicator	Change	Evidence
Temperature	$+1.1^{s}ince1880$	Global temperature records

Sea level	+21 cm since 1900	Satellite measurements
Arctic ice	-13% per decade	Satellite imagery

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

- **Temperature rise**: Global average temperature increase
- **Weather extremes**: More frequent hurricanes, droughts, floods
- **Ecosystem changes**: Species migration, habitat loss

Primary cause: Increased greenhouse gas emissions from fossil fuel burning, deforestation, industrial processes.

Mnemonic

"TSE" (Temperature-Sea level-Ecosystem)

Question 4(b) OR [4 marks]

Write some of measures to control global warming.

Solution

Table 25: Global Warming Control Measures

Category	Measures	Impact
Energy	Renewable sources, efficiency	Reduce CO2 emissions
Transport	Electric vehicles, public transport	Lower fuel consumption
Industry	Clean technology, carbon capture	Emission reduction
Individual	Energy conservation, lifestyle changes	Cumulative effect

Control measures:
Government level:

- **Policy frameworks**: Carbon pricing, emission standards
- **Renewable energy**: Solar, wind power promotion
- **Public transport**: Mass transit system development

Industrial level:

- **Clean technology**: Efficient processes, waste reduction
- **Carbon capture**: Storage and utilization technologies
- **Sustainable practices**: Green manufacturing, circular economy

Individual level:

- **Energy conservation**: LED lights, efficient appliances
- **Transportation**: Walking, cycling, carpooling
- **Lifestyle changes**: Reduced consumption, recycling

Mnemonic

"PRT-CCS-ECL" (Policy-Renewable-Transport, Carbon-Clean-Sustainable, Energy-Communication-Lifestyle)

Question 4(c) OR [7 marks]

Which are some important agreements for mitigating climate change at global level?

Solution

Table 27: Major Climate Agreements

Agreement	Year	Key Features
UNFCCC	1992	Framework convention

Kyoto Protocol	1997	Binding emission targets
Paris Agreement	2015	Global temperature limit

Important global climate agreements:

1. **United Nations Framework Convention on Climate Change (UNFCCC) - 1992**:
   - **Objective**: Stabilize greenhouse gas concentrations
   - **Principles**: Common but differentiated responsibilities
   - **Framework**: Foundation for future climate negotiations
2. **Kyoto Protocol - 1997**:
   - **Binding targets**: Developed countries reduce emissions by 5.2% (1990 levels)
   - **Flexible mechanisms**: Emissions trading, clean development mechanism
   - **Commitment periods**: First (2008-2012), Second (2013-2020)
3. **Paris Agreement - 2015**:
   - **Temperature goal**: Limit global warming to well below $2^{\cdot preferably}1.5$
   - **Nationally Determined Contributions (NDCs)**: Countries set own targets
   - **Review mechanism**: Five-year assessment and enhancement cycles
   - **Climate finance**: $100 billion annually for developing countries
4. **Other significant agreements**:
   - **Montreal Protocol (1987)**: Ozone layer protection, indirect climate benefits
   - **Copenhagen Accord (2009)**: Political agreement on emission reductions
   - **Doha Amendment (2012)**: Extended Kyoto Protocol commitments

Implementation challenges:

- **Compliance**: Voluntary vs mandatory commitments
- **Financing**: Adequate funding for mitigation and adaptation
- **Technology transfer**: Clean technology access for developing countries
- **Monitoring**: Transparent reporting and verification systems

Recent developments:

- **Article 6 rules**: International carbon markets under Paris Agreement
- **Loss and damage**: Support for climate-vulnerable countries
- **Net-zero commitments**: Countries pledging carbon neutrality

Mnemonic

"UKPOM-CDOG-TFMC" (UNFCCC-Kyoto-Paris-Other-Montreal, Copenhagen-Doha-Other-Goals, Technology-Finance-Monitoring-Commitments)

Question 5(a) [3 marks]

Explain effects of ozone layer depletion.

Solution

Table 29: Ozone Depletion Effects

Impact Area	Effect	Consequence
Human health	Increased UV-B radiation	Skin cancer, cataracts
Environment	Ecosystem disruption	Marine food chain damage
Agriculture	Crop damage	Reduced food production

Ozone layer depletion results in increased ultraviolet-B (UV-B) radiation reaching Earth's surface.
Effects:

- **Human health**: Higher skin cancer rates, eye damage, immune system suppression
- **Marine ecosystems**: Phytoplankton reduction affects ocean food chains
- **Agricultural impact**: Reduced crop yields, plant growth inhibition

Cause: Chlorofluorocarbons (CFCs) destroy ozone molecules in stratosphere.

Mnemonic

"HMA" (Human-Marine-Agricultural)

Question 5(b) [4 marks]

Write short note on greenhouse gases.

Solution

Table 31: Major Greenhouse Gases

Gas	Sources	Global Warming Potential
CO2	Fossil fuels, deforestation	1 (reference)
CH4	Agriculture, landfills	25 times CO2
N2O	Fertilizers, combustion	298 times CO2
F-gases	Industrial processes	1,000-20,000 times CO2

Greenhouse gases are atmospheric compounds that trap heat radiated from Earth's surface.
Major greenhouse gases:

- **Carbon dioxide (CO2)**: Most abundant, from fossil fuel burning
- **Methane (CH4)**: Potent but shorter-lived, from agriculture
- **Nitrous oxide (N2O)**: Long-lived, from fertilizers and industry
- **Fluorinated gases**: Very potent, from refrigeration and industrial uses

Properties: Absorb infrared radiation, transparent to visible light, varying atmospheric lifespans.
Global warming potential: Measures heat-trapping capacity relative to CO2 over specific time periods.

Mnemonic

"CMNF" (Carbon dioxide-Methane-Nitrous oxide-Fluorinated gases)

Question 5(c) [7 marks]

Explain Concept of 5R.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[5R Concept] {-{-}{} B[Refuse]}
    A {-{-}{} C[Reduce]}
    A {-{-}{} D[Reuse]}
    A {-{-}{} E[Repurpose]}
    A {-{-}{} F[Recycle]}
    B {-{-}{} G[Avoid unnecessary items]}
    C {-{-}{} H[Minimize consumption]}
    D {-{-}{} I[Use items multiple times]}
    E {-{-}{} J[Find new uses]}
    F {-{-}{} K[Process into new products]}
{Highlighting}
{Shaded}
```

5R Concept is a waste management hierarchy that prioritizes waste prevention and resource conservation.
The Five R's in order of priority:

1. **Refuse**:
   - **Definition**: Avoid accepting unnecessary items
   - **Examples**: Single-use plastics, promotional freebies, excessive packaging
   - **Impact**: Prevents waste generation at source
2. **Reduce**:
   - **Definition**: Minimize consumption and waste production
   - **Examples**: Buy only needed items, choose durable products, energy conservation
   - **Impact**: Decreases resource extraction and waste volume
3. **Reuse**:
   - **Definition**: Use items multiple times in their original form

- **Examples**: Glass jars for storage, clothing donation, furniture repurposing
- **Impact**: Extends product lifespan, reduces replacement needs

4. **Repurpose**:
   - **Definition**: Find new applications for items instead of discarding
   - **Examples**: Tire planters, bottle vases, cardboard organizers
   - **Impact**: Creative waste diversion, artistic value addition
5. **Recycle**:
   - **Definition**: Process waste materials into new products
   - **Examples**: Paper recycling, metal recovery, plastic reprocessing
   - **Impact**: Resource recovery, reduced landfill burden

Benefits of 5R approach:
- **Environmental**: Reduced pollution, resource conservation, ecosystem protection
- **Economic**: Cost savings, job creation in recycling industry
- **Social**: Community awareness, sustainable lifestyle promotion

Implementation hierarchy: Focus on refuse and reduce first (prevention), then reuse and repurpose (waste diversion), finally recycle (waste processing).
Challenges: Behavioral change requirements, infrastructure development, economic incentives alignment.

Mnemonic

"Real Recycling Requires Refusing Rubbish" (Refuse-Reduce-Reuse-Repurpose-Recycle)

Question 5(a) OR [3 marks]

Write salient features of wild life protection act, 1972.

Solution

Table 33: Wildlife Protection Act 1972 Features

Feature	Description	Penalty
Protected species	Scheduled animals/plants	Fine + imprisonment
Hunting ban	Prohibition of hunting	Up to 7 years jail
Trade regulation	Wildlife product trade control	Confiscation + fine

Wildlife Protection Act, 1972 provides legal framework for conservation of wildlife in India.
Salient features:
- **Species protection**: Six schedules categorizing species by protection level
- **Hunting prohibition**: Complete ban on hunting of protected species
- **Habitat conservation**: Protected areas designation and management
- **Trade control**: Regulation of wildlife product commerce

Enforcement: Wildlife Crime Control Bureau, forest departments, special courts for wildlife offenses.
Amendments: Regular updates to include new species and strengthen provisions.

Mnemonic

"SHTE" (Species-Hunting-Trade-Enforcement)

Question 5(b) OR [4 marks]

Which are the environmental policies in India?

Solution

Table 35: Major Environmental Policies in India

Policy	Year	Focus Area
National Environment Policy	2006	Comprehensive framework
National Water Policy	2012	Water resource management

National Forest Policy	1988	Forest conservation
National Action Plan on Climate Change	2008	Climate change mitigation

Major environmental policies:
National Environment Policy (2006):
- **Objective**: Sustainable development with environmental protection
- **Principles**: Polluter pays, precautionary approach
- **Implementation**: Integration across sectors

Sectoral policies:
- **National Water Policy**: Integrated water resource management
- **National Forest Policy**: 33% forest cover target
- **National Solar Mission**: Renewable energy promotion
- **Waste Management Rules**: Solid waste, e-waste, plastic waste management

Regulatory framework: Environment Protection Act, Water Act, Air Act, Forest Conservation Act.

Mnemonic

"NWFS" (National-Water-Forest-Solar)

Question 5(c) OR [7 marks]

Explain rainwater harvesting in detail.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Rainfall] {-{-}{} B[Catchment Area]}
    B {-{-}{} C[Collection System]}
    C {-{-}{} D[First Flush Diverter]}
    D {-{-}{} E[Filtration]}
    E {-{-}{} F[Storage Tank]}
    F {-{-}{} G[Distribution]}
    H[Recharge Pit] {-{-}{} I[Groundwater]}
    C {-{-}{} H}
{Highlighting}
{Shaded}
```

Rainwater harvesting is the collection, storage, and utilization of rainwater for beneficial purposes.
Components of rainwater harvesting system:
1. **Catchment area**:
   - **Function**: Surface for rain collection (rooftops, open areas)
   - **Material**: Should be clean, non-toxic (avoid asbestos, lead-painted surfaces)
   - **Calculation**: Collection = Catchment area $\times Rainfall \times Runoff coefficient$
2. **Collection and conveyance system**:
   - **Gutters**: Channel water from catchment surface
   - **Downspouts**: Vertical pipes carrying water from gutters
   - **Transportation**: Pipes connecting different components
3. **First flush diverter**:
   - **Purpose**: Removes initial dirty water containing debris
   - **Types**: Manual valve, automatic diverter, floating ball system
   - **Capacity**: Usually 10-15 liters per 100 sq.m of roof area
4. **Filtration system**:
   - **Coarse filter**: Removes leaves, debris (mesh screen)
   - **Fine filter**: Sand, gravel, activated carbon
   - **Slow sand filter**: Biological treatment for drinking water
5. **Storage system**:

- **Surface storage**: Tanks, reservoirs above ground
- **Underground storage**: Sumps, cisterns below ground
- **Material**: Ferrocement, plastic, concrete, fiberglass

Types of rainwater harvesting:

A. Rooftop harvesting:
- **Direct storage**: Rainwater stored in tanks for immediate use
- **Indirect recharge**: Water directed to recharge groundwater

B. Surface water harvesting:
- **Check dams**: Small barriers across streams
- **Percolation tanks**: Artificial recharge structures
- **Contour bunding**: Soil conservation with water harvesting

Benefits:
- **Water security**: Reduces dependence on external water sources
- **Groundwater recharge**: Prevents water table decline
- **Flood control**: Reduces surface runoff and urban flooding
- **Quality improvement**: Generally better than groundwater in polluted areas
- **Cost-effective**: Lower than water supply schemes
- **Energy saving**: Reduces pumping requirements

Design considerations:
- **Rainfall pattern**: Seasonal distribution, intensity
- **Water demand**: Household requirements, usage patterns
- **Storage capacity**: Based on dry period duration
- **Quality requirements**: Potable vs non-potable use
- **Site conditions**: Space availability, soil permeability

Maintenance requirements:
- **Regular cleaning**: Gutters, filters, storage tanks
- **Roof maintenance**: Prevent contamination sources
- **System inspection**: Check for leaks, blockages
- **Water quality testing**: Periodic analysis for potable use

Government initiatives:
- **Building codes**: Mandatory rainwater harvesting in new constructions
- **Subsidies**: Financial incentives for installation
- **Awareness programs**: Community education and training
- **Technical support**: Design guidelines, implementation assistance

Challenges:
- **Initial cost**: Setup expenses for complete system
- **Maintenance**: Regular upkeep requirements
- **Space requirements**: Storage tank space needs
- **Seasonal availability**: Dependence on monsoon patterns
- **Quality concerns**: Potential contamination issues

Calculation example:
- Roof area: 100 sq.m
- Annual rainfall: 1000 mm
- Runoff coefficient: 0.8
- Harvestable water = $100 \times 1 \times 0.8 = 80,000 liters/year$

Mnemonic

"CCFFS-RSBD-WGFQC-RCSMQ" (Catchment-Collection-Flush-Filter-Storage, Rooftop-Surface-Benefits-Design, Water-Groundwater-Flood-Quality-Cost, Regular-Check-System-Maintenance-Quality)