Chapter 12:

Environmental Chemistry- Water

Short Questions (Exercise)

2 (i) List the impurities present in rainwater.

- Dust particles
- Dissolved gases (e.g., CO_2, SO_2, NO_2)
- Pollutants like acid rain components (sulfuric and nitric acids)
- Microorganisms and organic matter

Example: Acid rain contains dissolved SO_2 and NO_2, which form sulfuric and nitric acids.

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2 (ii) List toxic substances present in household wastes.

- Cleaning agents (chlorine, ammonia)
- Pesticides and herbicides
- Plastic and microplastics
- Heavy metals from batteries (e.g., mercury, lead)

Example: Mercury from disposed batteries contaminates soil and water.

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2 (iii) In what ways do industrial wastes pollute water?

- Discharge of heavy metals (e.g., arsenic, lead, cadmium)
- Release of toxic chemicals like dyes, detergents, and acids
- Oil spills from factories
- Thermal pollution from hot water released by industries

Example: Textile industries discharge dyes into rivers, harming aquatic life.

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2 (iv) What is water pollution?

Water pollution is the contamination of water bodies like rivers, lakes, and oceans with harmful substances such as chemicals, sewage, and industrial waste, making it unsafe for use.

Example: Agricultural runoff introduces fertilizers into rivers, causing eutrophication.

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2 (v) List some waterborne diseases.

- Cholera
- Typhoid
- Dysentery
- Hepatitis A

Example: Cholera outbreaks are often caused by drinking contaminated water.

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2 (vi) What are pathogenic microorganisms?

Pathogenic microorganisms are disease-causing organisms, such as:

- Bacteria (e.g., Vibrio cholerae)
- Viruses (e.g., Hepatitis A virus)
- Protozoa (e.g., Giardia)
- Fungi

Example: Giardia causes severe diarrhea through contaminated water.

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3. How does tap water differ from distilled water?

- **Tap Water**: Contains minerals, chlorine, and impurities, but is treated to be safe for drinking.
- **Distilled Water**: Purified by boiling and condensation, free from minerals and impurities, but lacks essential nutrients.

Example: Tap water contains fluoride for dental health, while distilled water is often used in laboratories.

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4. Why are municipal water supplies treated with aluminum sulfate?

Aluminum sulfate is used in water treatment for:

- **Coagulation**: It helps clump impurities into larger particles (flocs) that can be easily removed.
- **Improving clarity**: Reduces turbidity and makes water clean.

Example: Alum is commonly added to water treatment tanks to purify drinking water.

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5. What are some health effects of biological contamination of water?

- **Diseases**: Causes waterborne illnesses like cholera, typhoid, and dysentery.
- **Gastrointestinal issues**: Ingesting contaminated water leads to diarrhea and vomiting.
- **Immune suppression**: Long-term exposure weakens immunity.

Example: Pathogens like E. coli in water can cause severe stomach infections.

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6. Identify the negative effects of water pollutants on life.

- **Aquatic Life**: Reduces oxygen levels, harming fish and plants.
- **Human Health**: Causes diseases like cancer, liver damage, and neurological disorders from heavy metals.
- **Ecosystems**: Disrupts natural food chains and reduces biodiversity.

Example: Oil spills suffocate marine life by blocking oxygen exchange.

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7. Water scarcity is an important issue in Pakistan. Give your comments on it.

Water scarcity in Pakistan is caused by:

- **Overpopulation**: Increased demand for water in urban and rural areas.
- **Climate Change**: Reduced rainfall and melting glaciers affect water availability.
- **Mismanagement**: Wastage of water in agriculture and industries.

Example: The Indus River faces depletion due to overuse and climate impacts, affecting millions of farmers.

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8. What are fertilizers?

Fertilizers are chemical or natural substances added to soil to enhance its fertility and promote plant growth.

- **Types**:
    - Chemical (e.g., urea, NPK fertilizers)
    - Organic (e.g., manure, compost)

Example: Nitrogen-based fertilizers increase crop yields but can cause water pollution if overused.

Think Tanks And Project

9. Public health depends on water quality. Give arguments.

Arguments:

1. **Disease Prevention**: Clean water prevents waterborne diseases like cholera, typhoid, and dysentery. Contaminated water is a significant cause of illness in developing countries.
2. **Hygiene and Sanitation**: Access to clean water is essential for maintaining personal and public hygiene. Dirty water spreads harmful microorganisms.
3. **Food Safety**: Irrigating crops with polluted water introduces toxins and pathogens into the food supply.

Example: During the 2010 Haiti cholera outbreak, contaminated drinking water was the primary cause of the disease.

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10. How does chemistry help maintain a clean swimming pool? Explain.

Explanation:

1. **Chlorination**: Adding chlorine to pool water kills bacteria, viruses, and algae, keeping the water safe for swimmers.
2. **pH Balance**: Chemicals like sodium bicarbonate are used to maintain the pool's pH between 7.2–7.8 to prevent skin and eye irritation.
3. **Algaecides**: Special chemical agents prevent algae growth in the pool.
4. **Filtration Assistance**: Coagulants help trap small impurities, improving water clarity.

Example: Regular chlorination prevents the growth of harmful microorganisms like E. coli in swimming pools.

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11. It is advisable to wash hands well with soap after using bathrooms. Evaluate it.

Evaluation:

1. **Hygiene Importance**: Washing hands with soap removes germs, preventing the spread of diseases like diarrhea and respiratory infections.
2. **Soap Efficiency**: Soap breaks down grease and dirt on hands and kills harmful microorganisms.
3. **Global Health Standards**: Organizations like WHO emphasize handwashing as a simple, effective way to save lives by reducing infections.

Example: During the COVID-19 pandemic, regular handwashing significantly reduced the transmission of the virus.

Project: Create a Chart Showing Water Pollution Model

To create the chart, follow these components:

Components of Water Pollution Model

1. **Sources of Pollution**: Industrial waste, agricultural runoff, sewage, oil spills.
2. **Pathways**: Pollutants enter rivers, lakes, and oceans through runoff, pipelines, or direct dumping.
3. **Effects**: Harmful impacts on aquatic life, human health, and ecosystems.
4. **Solutions**: Wastewater treatment, sustainable agriculture, and awareness programs.

Chart Example: A simple flow diagram can show sources leading to effects and possible solutions. You can watch the referenced video for additional inspiration.

Extera Short Questions (Topic Wise)

12.1: Properties of Water

1. Why is water called the universal solvent?

Water is called the universal solvent because it can dissolve a wide variety of substances due to its polarity and hydrogen bonding. This property makes it essential for biochemical reactions in living organisms.
Example: Salt (NaCl) dissolves easily in water, forming Na^+ and Cl^- ions.

2. What is the importance of the high specific heat of water?

Water's high specific heat allows it to absorb and release large amounts of heat without a significant temperature change, helping regulate Earth's climate and body temperatures in living organisms.
Example: Coastal areas have milder climates due to the heat-absorbing properties of water in the ocean.

3. How does surface tension benefit aquatic life?

Surface tension, caused by hydrogen bonding, allows water to resist external forces. This property enables small organisms like insects to walk on water surfaces.
Example: Pond skaters rely on surface tension to move across water without sinking.

4. Why is the density anomaly of water important for aquatic ecosystems?

Water is less dense as a solid (ice) than as a liquid, allowing ice to float on water. This insulates the water below and helps aquatic life survive in freezing temperatures.
Example: Lakes freeze from the top down, protecting fish and other organisms in the water below.

5. What is the role of water in regulating Earth's climate?

Water's ability to absorb heat without rapidly changing temperature helps maintain a stable climate, preventing extreme temperature fluctuations.
Example: The Gulf Stream carries warm water across the Atlantic, moderating temperatures in Europe.

12.2: Treatment of Domestic Water Supply

1. What is coagulation in water treatment?

Coagulation is the process of adding chemicals like alum to water, which causes impurities to clump together into larger particles (flocs) that are easier to remove.
Example: Alum is commonly used in municipal water plants for coagulation.

2. How does filtration work in water treatment?

Filtration removes small particles and impurities by passing water through layers of sand, gravel, and activated carbon. This step improves water clarity and taste.
Example: Household water filters often use activated carbon to remove impurities.

3. Why is disinfection an essential step in water treatment?

Disinfection kills harmful microorganisms, such as bacteria and viruses, ensuring that the water is safe for human consumption. Chlorine or UV light is commonly used for this purpose.
Example: Chlorinated water prevents diseases like cholera and typhoid.

4. What is the purpose of sedimentation in water treatment?

Sedimentation allows heavy particles and flocs to settle at the bottom of the treatment tank, making the water clearer and easier to filter.
Example: This process is often used after coagulation to remove larger particles.

5. Why is water storage important after treatment?

Water is stored in clean reservoirs or tanks to ensure it remains safe and is available for distribution when needed.
Example: Cities store treated water in overhead tanks for daily supply to homes.

12.3: Water Pollution and Its Effects

1. What are the main causes of water pollution?

Water pollution is caused by industrial waste, agricultural runoff, domestic sewage, and oil spills. These contaminants degrade water quality and harm ecosystems.
Example: Fertilizer runoff from farms causes eutrophication in nearby lakes.

2. How does water pollution affect human health?

Contaminated water can lead to diseases like cholera, dysentery, and hepatitis, especially in areas without proper water treatment facilities.
Example: In 2010, a cholera outbreak in Haiti was linked to contaminated drinking water.

3. What is eutrophication, and how does it harm aquatic ecosystems?

Eutrophication occurs when excess nutrients (like nitrates and phosphates) enter water bodies, causing algae blooms that deplete oxygen and harm aquatic life.
Example: The Gulf of Mexico's "dead zone" is caused by nutrient runoff from the Mississippi River.

4. What are the effects of oil spills on aquatic life?

Oil spills coat the surface of water, blocking sunlight and oxygen exchange, which severely affects marine life like fish, birds, and plants.
Example: The Deepwater Horizon oil spill in 2010 caused massive destruction to marine ecosystems in the Gulf of Mexico.

5. How does industrial waste contribute to water pollution?

Industries discharge heavy metals, chemicals, and toxins into rivers and lakes, making the water unsafe for consumption and harming aquatic organisms.
Example: The Citarum River in Indonesia is one of the most polluted rivers due to industrial waste.

Extera Long Questions (Topic Wise)

1. The Properties of Water and Their Significance

Water (H_2O) is a unique compound essential for the survival of life on Earth. Its chemical and physical properties make it indispensable for various biological, ecological, and environmental processes.

1.1 High Specific Heat

Water has a high specific heat capacity, meaning it can absorb and retain heat without significant temperature change. This property plays a critical role in:

- **Regulating Climate**: Large bodies of water like oceans absorb heat during the day and release it slowly at night, preventing extreme temperature variations.
- **Stabilizing Body Temperature**: In organisms, water helps maintain a constant internal temperature despite external fluctuations.

Example: Coastal regions experience milder weather compared to inland areas due to the heat-absorbing ability of nearby oceans.

1.2 Solvent Properties

Water is called the "universal solvent" because it dissolves a wide range of substances, making it essential for chemical reactions and nutrient transport.

- **Biological Relevance**: In the human body, water dissolves and transports nutrients, hormones, and oxygen to cells while removing waste products.
- **Environmental Importance**: Water dissolves minerals and gases, supporting aquatic ecosystems and biochemical cycles.

Example: Sodium chloride (table salt) dissolves in water, breaking into Na^+ and Cl^- ions, which plants and animals use for metabolic processes.

1.3 Surface Tension

The cohesive forces between water molecules create surface tension, allowing water to resist external forces.

- **Ecological Benefits**: Surface tension supports small organisms like insects that can walk on water.
- **Practical Applications**: It enables capillary action, where water rises through narrow tubes or spaces, aiding plants in transporting water from roots to leaves.

Example: Water droplets form spherical shapes due to surface tension, a property utilized in nature and industry.

1.4 Density Anomaly

Water is most dense at 4°C, and ice is less dense than liquid water. This property is crucial for aquatic ecosystems.

- **Aquatic Life Protection**: Ice forms on the surface of lakes and ponds, insulating the water below and enabling organisms to survive in cold climates.
- **Ecosystem Stability**: Floating ice prevents entire water bodies from freezing, preserving biodiversity.

Example: The Arctic Ocean's floating ice supports marine life even in extreme temperatures.

Conclusion

Water's unique properties—high specific heat, solvent abilities, surface tension, and density anomaly—are vital for life on Earth. These features regulate the climate, support biological processes, and sustain ecosystems.

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2. Water Pollution: Causes, Effects, and Solutions

Water pollution occurs when harmful substances contaminate water bodies, making them unfit for consumption and damaging ecosystems. It is one of the most pressing environmental challenges today.

2.1 Causes of Water Pollution

1. **Industrial Waste**: Factories discharge heavy metals, chemicals, and toxins directly into rivers and lakes, polluting water sources.
2. **Agricultural Runoff**: Fertilizers and pesticides used in farming wash into water bodies, introducing harmful chemicals and nutrients.
3. **Sewage and Domestic Waste**: Untreated sewage contains pathogens and organic waste that deplete oxygen levels in water.
4. **Oil Spills**: Accidents during oil drilling and transportation release crude oil into oceans, severely affecting marine life.

Example: The 2010 Deepwater Horizon oil spill polluted the Gulf of Mexico, killing marine life and damaging ecosystems.

2.2 Effects of Water Pollution

1. **Human Health Hazards**: Contaminated water leads to diseases like cholera, typhoid, and hepatitis, particularly in developing regions without access to clean water.
2. **Eutrophication**: Excess nutrients cause algae blooms, depleting oxygen levels and killing aquatic life.
3. **Loss of Biodiversity**: Pollutants disrupt food chains and habitats, leading to a decline in aquatic species.

4. **Economic Impact**: Water pollution affects fisheries, tourism, and clean-up costs, straining local economies.

Example: Eutrophication in the Baltic Sea has created "dead zones" where marine life cannot survive.

2.3 Solutions to Water Pollution

1. **Industrial Regulation**: Enforce laws to prevent industries from discharging untreated waste into water bodies.
2. **Sustainable Agriculture**: Use organic fertilizers and controlled irrigation to reduce runoff.
3. **Wastewater Treatment**: Establish treatment plants to clean domestic and industrial sewage before release.
4. **Public Awareness**: Educate communities about the importance of water conservation and pollution control.

Example: Singapore has implemented advanced wastewater treatment systems, turning sewage into clean drinking water.

Conclusion

Water pollution poses severe threats to ecosystems, human health, and economies. Addressing its causes through regulation, sustainable practices, and community involvement is essential to preserve this vital resource for future generations.

MCQS

12.1: Properties of Water

1. **What makes water a universal solvent?**
   a) It is a liquid
   b) It has low density
   c) **It can dissolve a wide variety of substances** ✔
   d) It has a high boiling point

2. **Which property of water helps regulate Earth's climate?**
   a) Surface tension
   b) **High specific heat** ✔
   c) Low density of ice
   d) Transparency

3. **Why does ice float on water?**
   a) It is made of air
   b) It is less dense than water
   c) **Ice has a lower density due to hydrogen bonding** ✔
   d) Ice has a higher temperature

4. **What causes surface tension in water?**
   a) Low boiling point
   b) Polarity
   c) **Hydrogen bonding** ✔
   d) Solubility

5. **What happens to water density as it cools below 4°C?**
   a) Increases
   b) **Decreases** ✔
   c) Stays constant
   d) Depends on the pressure

6. **What allows small insects to walk on water?**
   a) Capillary action
   b) **Surface tension** ✔
   c) Low viscosity
   d) High specific heat

7. **What property of water enables capillary action in plants?**
   a) Specific heat
   b) **Cohesion and adhesion** ✔
   c) Surface tension
   d) Solvent ability

8. **What is the boiling point of water at standard atmospheric pressure?**
   a) 50°C

b) 90°C
c) **100°C** ✔
d) 150°C

9. **Which property of water prevents extreme temperature fluctuations on Earth?**
   a) Solubility
   b) **High specific heat** ✔
   c) Density anomaly
   d) Surface tension

10. **Why is water important for living organisms?**
    a) It dissolves oxygen
    b) It regulates body temperature
    c) It transports nutrients
    d) **All of the above** ✔

12.2: Treatment of Domestic Water Supply

11. **What is the first step in water treatment?**
    a) Disinfection
    b) Filtration
    c) **Coagulation and flocculation** ✔
    d) Sedimentation

12. **Which chemical is commonly used for disinfection in water treatment?**
    a) Alum
    b) **Chlorine** ✔
    c) Sand
    d) Lime

13. **What is the purpose of sedimentation in water treatment?**
    a) Remove bacteria
    b) **Settle large particles** ✔
    c) Add minerals
    d) Kill microorganisms

14. **How does filtration improve water quality?**
    a) Removes harmful gases
    b) **Removes smaller impurities** ✔
    c) Adds oxygen
    d) Disinfects the water

15. **Which of the following removes organic and inorganic impurities in water?**
    a) Alum
    b) **Activated carbon filter** ✔
    c) Sedimentation
    d) Chlorine

16. **What is the role of alum in water treatment?**
    a) Disinfect the water
    b) **Cause impurities to clump together** ✔
    c) Filter the water
    d) Kill microorganisms

17. **What is a common method to kill bacteria in water?**
    a) Filtration
    b) Sedimentation
    c) **Chlorination** ✔
    d) Coagulation

18. **What is the purpose of UV light in water treatment?**
    a) Removes dirt
    b) **Kills microorganisms** ✔
    c) Neutralizes pH
    d) Removes heavy metals

19. **Why is storage important in water treatment?**
    a) Removes impurities
    b) Improves filtration
    c) **Ensures safe supply of treated water** ✔
    d) Adds minerals

20. **What process removes suspended solids in water treatment?**
    a) Disinfection
    b) **Sedimentation** ✔
    c) Chlorination
    d) Aeration

12.3: Water Pollution and Its Effects

21. **What is a major cause of water pollution?**
    a) Oil spills
    b) Industrial discharge
    c) Agricultural runoff
    d) **All of the above** ✔

22. **Which pollutant causes eutrophication?**
    a) Heavy metals
    b) Pesticides
    c) **Nitrates and phosphates** ✔
    d) Oil

23. **What is the impact of eutrophication?**
    a) Decrease in oxygen levels
    b) Algae blooms
    c) Death of aquatic life
    d) **All of the above** ✔

24. **How does sewage affect water quality?**
    a) Reduces oxygen levels
    b) Spreads diseases
    c) Introduces harmful microorganisms
    d) **All of the above** ✔

25. **What is one major effect of oil spills?**
    a) Increased oxygen levels
    b) **Blocking sunlight and oxygen exchange** ✔
    c) Neutralizing pH
    d) Fertilizing aquatic plants

26. **Which disease is caused by contaminated water?**
    a) Malaria
    b) **Cholera** ✔
    c) Dengue
    d) Tuberculosis

27. **What is the impact of industrial waste on water?**
    a) Improves pH
    b) **Contaminates water with heavy metals** ✔
    c) Kills pathogens
    d) Improves oxygen levels

28. **What happens in eutrophication?**
    a) Algae die and release oxygen
    b) **Nutrients increase algae growth, depleting oxygen** ✔
    c) Water bodies clear up
    d) Aquatic plants grow faster

29. **How does water pollution affect aquatic life?**
    a) Improves oxygen exchange
    b) Enhances biodiversity
    c) **Reduces survival due to lack of oxygen** ✔
    d) None of the above

30. **Which of the following is an effective solution to water pollution?**
    a) Dumping waste in rivers
    b) Using untreated sewage
    c) **Installing wastewater treatment plants** ✔
    d) Spraying pesticides near water bodies