UGC NET EVS Memory Based Question -7 JAN 2026 SHIFT -2

Q1. Regarding tidal energy, which of the following statements are accurate?
A. Tidal energy harnesses the kinetic energy of ocean currents caused by tides.
B. Tidal barrages are structures that essentially trap high tide water and release it through turbines.
C. Tidal stream generators work similarly to underwater wind turbines.
D. The gravitational pull of the Moon is the primary driver of Earth's tides.
Choose the correct answer from the options given below:
(A). A, B and C Only
(B). B, C and D Only
(C). A, C and D Only
(D). A, B, C and D
Answer: d
Solution:
Introduction:

- Tidal energy is a form of hydropower that converts the energy obtained from tides into useful forms of power, mainly electricity.
- The world's first large-scale tidal power plant was the Rance Tidal Power Station in France, which started operation in 1966.

Information Booster:

- Kinetic energy of tides: Tidal energy captures the energy of water movement caused by the rhythmic rise and fall of ocean tides.
- Tidal barrages: These are large dams built across estuaries or bays, creating a basin. Water flows into the basin at high tide and is released through turbines at low tide, generating electricity.
- Tidal stream generators: These devices are placed in strong tidal currents and have rotors that are turned by the moving water, much like wind turbines are turned by moving air.
- **Tidal energy** is a form of **renewable energy** that harnesses the power of the **tides**—the rise and fall of sea levels caused by the gravitational forces of the moon and the sun.
- This energy source has been considered for centuries and is growing in interest as a sustainable energy option due to its reliability and predictability.
- Similar to underwater wind turbines, **tidal stream systems** use the kinetic energy of moving water to generate electricity.
- As tides flow in and out, the movement of water spins turbines placed in areas with high tidal currents, such as narrow straits or channels.
- Tidal energy is a **renewable resource**, meaning it is constantly replenished by the natural movement of tides.
- Unlike fossil fuels, tidal energy does not deplete over time, making it a long-term, sustainable energy solution.
- One of the most significant advantages of tidal energy is its **predictability**.
- Tides occur regularly and are influenced by the gravitational forces of the moon and the sun, which are highly predictable.

- Tidal energy systems, especially tidal stream systems, have a **low environmental impact** compared to other forms of energy generation.
- Tidal turbines do not produce greenhouse gases or harmful emissions during operation, and they require relatively minimal land use compared to wind or solar farms.
- Moreover, the operation of tidal energy systems does not significantly disturb marine life.

Additional Knowledge:

- Tidal energy is a predictable renewable energy source, as tides are governed by astronomical cycles.
- However, initial infrastructure costs can be high, and environmental impacts of barrages are a concern.

Q2. The formation of igneous rocks is controlled by the Bowen's Reaction Series. Which of the following statements accurately reflect principles of this series?
A. It describes the sequence in which minerals melt as temperature increases.
B. Discontinuous and continuous reaction series run simultaneously.
C. Quartz is the last mineral to crystallize from a cooling magma.
D. Olivine is the first ferromagnesian mineral to crystallize.
E. Plagioclase feldspar crystallizes in a series from calcium-rich to sodium-rich.
Choose the correct answer from the options given below:
(A). A, B and C Only
(B). B, D and E Only
(C). B, C and D Only
(D). C, D and E Only
Answer: b
Solution:

Introduction:

- Bowen's Reaction Series describes the order of crystallization of minerals from a cooling magma.
- **Bowen's Reaction Series** describes the sequence in which minerals crystallize from **a cooling magma.**
- The series is divided into two branches: the discontinuous and continuous series.
- It is based on the idea that as magma cools, different minerals crystallize at different temperatures in a predictable sequence.

Information Booster:

- The discontinuous series (olivine -> pyroxene -> amphibole -> biotite) and the continuous series (Ca-plagioclase -> Na-plagioclase) proceed concurrently as temperature drops.
- At the highest temperatures, olivine is the first mafic mineral to crystallize from a mafic magma.
- The plagioclase feldspars form a solid solution series. As temperature falls, the crystallizing plagioclase becomes progressively more sodium-rich.
- The discontinuous and continuous series run simultaneously during the cooling of magma.
- The discontinuous series involves minerals that undergo phase changes (such as olivine to pyroxene to amphibole to biotite).
- while the continuous series involves the plagioclase feldspar group, where the composition gradually changes from calcium-rich to sodium-rich as the magma cools.

Additional Knowledge:

- Bowen's Series describes the order of **crystallization**, not melting.
- While the melting order is generally the reverse, the series itself is a crystallization model.
- While quartz is near the bottom of the series, potassium feldspar and muscovite crystallize at similar or lower temperatures.
- In a typical granite magma, quartz is among the last to crystallize, but it is not definitively the absolute last in all cases.

Q3. Arrange the following biomes based on the amount of biomass stored in vegetation from LOWEST to HIGHEST.

A. Desert

B. Temperate Grassland

C. Taiga

D. Tropical Rainforest

Choose the correct answer from the options given below:

(A). A, B, C, D

(B). B, A, C, D

(C). D, C, B, A

(D). C, D, A, B

Answer: a

Solution:

Introduction:

- Biomass refers to the total mass of living organisms in a given area.
- It is closely related to NPP but refers to the standing crop.
- Different biomes store varying amounts of biomass in their vegetation based on factors such as climate, precipitation, and temperature.

Information Booster:

- **Taiga** being a vast forest, stores a huge amount of biomass in its trees.
- The Taiga, or boreal forest, has a moderate amount of biomass.
- It supports coniferous trees, which store more biomass than grasses but less than the dense vegetation of tropical rainforests.
- Deserthas the lowest biomass due to minimal plant growth.
- Deserts typically have very low biomass because they receive very little rainfall, which limits the growth of plants and vegetation.
- TemperateGrasslandhas high biomass stored in root systems, but lower above-ground biomass than forests.
- Grasslands receive more precipitation than deserts, they still don't support as much biomass as forests because they are dominated by grasses, which have relatively low biomass compared to trees.
- TropicalRainforest has the highest biomass of any terrestrial biome due to dense, year-round growth.
- Tropical rainforests have the highest biomass due to their warm temperatures and consistent rainfall, which support dense, tall trees and a wide variety of plant species.

Additional Knowledge:

- Grasslands have lower above-ground biomass, their below-ground (root) biomass can be very high.
- Oceans have low biomass per unit area but enormous total biomass due to their vast size.

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

A. Carbon Dioxide CO2

B. Methane CH4

C. Nitrous Oxide N2O

D. CFC-12{Dichlorodifluoromethane},{CCl,F2

E. Sulfur Hexafluoride SF6

Choose the correct answer from the options given below:

(A). E, D, C, B, A

(B). D, E, C, B, A

(C). E, C, D, B, A

(D). C, E, D, B, A

Answer: a

Solution:

Introduction:

- Global Warming Potential (GWP) is a measure used to compare the climate forcing potential of different greenhouse gases (GHGs) relative to CO2 over a defined time period, typically 100 years.
- GWP depends on the gas's ability to absorb infrared radiation and its atmospheric lifetime.

Information Booster:

- The relative Global Warming Potentials (GWP100) values, approximate mid-range for clarity) establish the ranking: SF6≫CFC-12≫N2O≫CH4≫CO2
- **Sulfur Hexafluoride (SF6\text{SF}_6SF6):**GWP100≈25,200
- Highest GWP due to extremely long atmospheric lifetime (~3,200years) and high radiative efficiency.
- **D. CFC-12:**GWP100≈10,200.
- High GWP from a long lifetime and strong absorption; also an Ozone Depleting Substance (ODS).
- Nitrous Oxide (N2O) GWP100≈273 . Moderately high GWP, mainly sourced from agriculture (fertilizers) and industry.
- Methane (CH4):GWP100≈27–30
- Low GWP compared toSF6, but high short-term impact due to its high radiative efficiency and relatively short atmospheric lifetime (~12years)
- Carbon Dioxide (CO2) :GWP100=1.It is the reference gas and the largest overall contributor to global warming by radiative forcing due to its vast quantity.

is mainly used in the electrical power industry as an insulating medium. SF6

- Gases with the highest GWP generally have the longest atmospheric lifetimes, such as Perfluorocarbons (PFCs) and **SF6** While CH4 has a much lower GWP than SF6 or CFC-12 its total Radiative Forcing is significant due to high emission rates.

Q5. Match the following EIA process steps with their primary objectives:

LIST-I (EIA Process Step)	LIST-II (Primary Objective)
A. Screening	I. To define the key issues and boundaries for the EIA study.
B. Scoping	II. To identify, predict, and evaluate the significance of impacts.
C. Impact Analysis	III. To propose measures to avoid, reduce, or compensate for adverse impacts.
D. Mitigation	IV. To determine whether a project requires a full-scale EIA or not.

Choose the correct answer from the options given below:

(A). A - I, B - II, C - III, D - IV

(B). A - IV, B - I, C - II, D - III

(C). A - II, B - IV, C - I, D - III

(D). A - III, B - I, C - IV, D - II

Answer: b

Solution:

Introduction:

- The **Environmental Impact Assessment (EIA)** is a systematic process used to evaluate the potential environmental effects of a proposed project or development before it is carried out.
- The objective of the EIA process is to ensure that environmental factors are considered in decision-making, allowing for informed choices that minimize adverse impacts on the environment and human health.

Information Booster:

- Screening: To determine whether a project requires a full-scale EIA or not.
- Scoping: To define the key issues and boundaries for the EIA study.
- Impact Analysis : To identify, predict, and evaluate the significance of impacts.
- Mitigation: To propose measures to avoid, reduce, or compensate for adverse impacts.
- Screening is the initial step in the EIA process.
- Its purpose is to decide whether a project should undergo a full-scale Environmental Impact Assessment (EIA) based on its size, potential environmental impacts, and other factors.
- It helps identify projects that may have significant environmental effects and need further assessment.
- Scoping is the process of identifying the key environmental issues and impacts that will be studied in the EIA.
- It helps set the Terms of Reference (ToR) for the EIA study, determining the focus, methodology, and the spatial and temporal boundaries of the study.
- Impact Analysis involves identifying the potential environmental impacts of the project, predicting their significance, and evaluating their effects.
- It helps assess how the project could affect air, water, land, biodiversity, and communities.
- The analysis also looks at the severity and duration of potential impacts.
- Mitigation focuses on proposing actions to minimize or eliminate the negative impacts of the project.
- This could include reducing the scale of the project, using technology to reduce pollution, or compensating for any environmental losses (e.g., restoring habitats, creating wildlife corridors).

Q6. Regarding hydropower plants, which of the following statements are generally correct?
A. Hydropower plants convert the potential energy of stored water into electrical energy.
B. Run-of-river hydropower plants typically require large reservoirs.
C. Pumped-storage hydropower plants are used for energy storage and grid balancing.
D. Hydropower is considered a clean energy source as it does not produce air pollution during operation.
Choose the correct answer from the options given below:
(A). A, B and C Only
(B). A, C and D Only
(C). B, C and D Only
(D). A, B, C and D
Answer: b
Solution:
Introduction:

- Hydropower (hydroelectric power) is electricity generated from the movement of water.
- Hydropower plants capture the energy of falling water to generate electricity.
- A turbine converts the kinetic energy of falling water into mechanical energy.
- Then a generator converts the mechanical energy from the turbine into electrical energy.

Information Booster:

- Energy conversion: Hydropower plants primarily harness the potential energy of water stored at a height (behind a dam) and convert it into kinetic energy as it flows, which then drives turbines to generate electricity.
- Pumped-storage: These systems store energy by pumping water from a lower reservoir to an upper one when electricity demand is low.
- When demand is high, the water is released back down through turbines to generate power, thus acting as a large-scale battery.
- Clean energy: During operation, conventional hydropower plants do not produce air pollutants or greenhouse gases.
- However, the construction of dams can have significant environmental impacts (e.g., habitat loss, changes in river ecosystems).

Additional knowledge:

- Run-of-river plants: These plants use the natural flow of a river, often with little or no water storage.
- They divert a portion of river water through a canal or pipeline to a powerhouse and then return it to the river, thus requiring minimal or no reservoir.

Q7. What is the primary product of composting organic waste?
(A). Biogas
(B). Nutrient-rich manure
(C). Recycled plastic
(D). Refuse-derived fuel
Answer: b
Solution:

Introduction:

- Composting is a biological, aerobic decomposition process in which microorganisms (bacteria, fungi, and actinomycetes) break down the biodegradable organic fraction of solid waste such as kitchen scraps, agricultural residues, leaves, and paper into a stable, humus-like substance.

Information Booster:

- Composting is one of the most important biological treatment methods for organic solid waste, alongside vermicomposting and biomethanation.
- It plays a crucial role in integrated solid waste management (ISWM) and supports circular economy principles by returning nutrients to the soil.
- The primary product of this process is a nutrient-rich organic manure or compost, which serves as an excellent soil conditioner and fertilizer substitute.
- During composting: Organic matter (mainly carbohydrates, proteins, and fats) undergoes microbial oxidation in the presence of oxygen.
- Heat is generated, leading to the breakdown of complex organic compounds into simpler, stable forms of carbon, nitrogen, phosphorus, and other nutrients.
- The final product compost or nutrient-rich manure has:
- High organic carbon content,
- Balanced C/N ratio (≈10–15:1),
- Significant amounts of macro and micronutrients like nitrogen (N), phosphorus (P), and potassium (K).

Additional knowledge:

- Biogas: Produced through anaerobic digestion (biomethanation), not composting.
- This is a biochemical process without oxygen that yields methane (CH_4) and carbon dioxide (CO_2), not manure.
- Recycled Plastic: Recycling plastics involves mechanical or chemical reprocessing, not biological degradation. It has no relation to composting.
- Refuse-derived fuel (RDF): Produced by shredding, drying, and compacting combustible components of waste (like plastics, paper, textiles) for thermal energy recovery — a waste-to-energy process, not biological treatment.

Q8. Match List - I (Air Pollution Control Device) with List - II (Primary Particle Removal Mechanism).

List - I (Air Pollution Control Device)	List - II (Primary Particle Removal Mechanism)
(A) Cyclone Separator	(I) Coagulation and subsequent filtration/impaction of particles via a liquid medium.
(B) Electrostatic Precipitator (ESP)	(II) Acceleration of particles by centrifugal force due to swirling gas flow.
(C) Venturi Scrubber	(III) Migration of charged particles towards an electrode plate under the influence of an electric field.

(D) Fabric Filter (Baghouse)	(IV) Capture of particles on a porous medium by sieving, interception, and impaction.

Choose the correct answer from the options given below:
(A). (A)-(I), (B)-(III), (C)-(II), (D)-(IV)
(B). (A)-(II), (B)-(III), (C)-(I), (D)-(IV)
(C). (A)-(IV), (B)-(I), (C)-(III), (D)-(II)
(D). (A)-(III), (B)-(IV), (C)-(I), (D)-(II)
Answer: b
Solution:
Introduction:

- This question tests the technical understanding of Air Pollution Control Devices (APCDs), which are vital components in industrial environmental management.
- The principle that governs how each device removes Particulate Matter (PM) is fundamental to environmental engineering and defines the suitability of the technology for different pollution sources.

Information Booster:

- Cyclone Separator →Acceleration of particles by centrifugal force due to swirling gas flow.
- Cyclones convert linear gas velocity into a swirling vortex.
- The resulting centrifugal force throws the heavier particles outward toward the collector walls, where they slide down into a hopper.
- Electrostatic Precipitator (ESP) →Migration of charged particles towards an electrode plate under the influence of an electric field.
- ESPs first use a high-voltage electrode to electrically charge the particles.
- The charged particles are then driven by the strong electrostatic field toward grounded collecting plates.
- Venturi Scrubber → Coagulation and subsequent filtration/impaction of particles via a liquid medium.
- The gas stream is accelerated through a narrow Venturi throat where it atomizes a liquid.
- The high-velocity gas forces PM to impact and combine (coagulate) with the scrubbing liquid droplets, which are then easily removed.
- (Fabric Filter (Baghouse) → Capture of particles on a porous medium by sieving, interception, and impaction.
- Fabric filters operate by physical filtration. Particles are captured on the fabric surface (which builds a highly effective "filter cake") primarily through sieving (direct capture), interception, and impaction.

Q9. Choose the INCORRECT statement regarding the process of Solid Waste Incineration.
(A). The calorific value of the waste must be sufficiently high to sustain combustion without the need for supplementary fuel.
(B). Dioxins and Furans (PCDD/PCDFs), highly toxic Persistent Organic Pollutants (POPs), are formed during the incomplete combustion of chlorine-containing materials.
(C). The quantity of fly ash (finer particles captured by APCDs) generated during incineration is typically less voluminous than the quantity of bottom ash (uncombusted residue) that remains after combustion.
(D). Waste materials are combusted in a highly oxygen-starved environment to maximize the

conversion of carbon to Carbon Monoxide (CO) for energy recovery.
Answer: d
Solution:
Introduction:
- Incineration is a thermal treatment process for solid waste aimed at volume reduction, mass reduction, and energy recovery, though it requires strict control of air emissions.

Information Booster:
- Incineration is a form of combustion, which requires an excess of oxygen (aerobic condition) to achieve complete oxidation of organic matter toCO2andH2Oat high temperature((~850∘C).
- Burning in an oxygen-starved environment is characteristic of pyrolysis or gasification, not incineration, and leads to the production of CO and char, not necessarily maximized energy recovery in a typical incinerator.
- When waste is burned in an oxygen-starved environment, the process is no longer ordinary incineration—it becomes gasification, a controlled form of partial combustion.
- The goal of gasification is not to fully oxidize carbon into CO_2 but to stop the reaction halfway, producing a combustible gas mixture rich in carbon monoxide (CO) and hydrogen (H_2).
- This mixture is called syngas, and it can be used as a fuel for heat, electricity or chemical production.
- Here's the logic behind the chemistry.
- In full combustion, carbon goes all the way to CO_2 because oxygen is abundant:
- $C + O_2 \rightarrow CO_2$ (releases maximum energy per carbon atom)
- In gasification, oxygen is intentionally limited:
- $2C + O_2 \rightarrow 2CO$ (partial oxidation)
- This reaction still releases heat, but it preserves more chemical value because CO can be burned later or used industrially. It's similar to holding back the reaction so the energy is stored in the gas rather than released all at once.

Additional knowledge:
- Dioxin and Furan formation is minimized by maintaining high combustion temperatures and rapidly cooling the flue gases to bypass the temperature window(200∘Cto450∘C) where synthesis occurs.
- Bottom ash (heavier, non-combustible residue) accounts for most of the solid residue (by mass and volume), while Fly ash\text{Fly ash}Fly ash (lighter, hazardous residue) accounts for a smaller fraction but requires hazardous waste management protocols.

Q10. Which of the following are classified as Biofuels?
A. Biogas
B. Biodiesel
C. Bioethanol
D. Syngas
E. Natural Gas
Choose the correct answer from the options given below:
(A). A, B and C Only
(B). B, C and D Only
(C). C, D and E Only

(D). A, D and E Only
Answer: a
Solution:
Introduction:
- Biofuels are fuels derived directly from living or recently living biological material (biomass).
- They are renewable and can reduce dependence on fossil fuels.
- Biofuels generally produce fewer greenhouse gas emissions compared to fossil fuels.
- They can be produced from waste materials, reducing waste disposal problems.

Information Booster:
- Biodiesel is a biofuel made from vegetable oils, animal fats, or recycled grease.
- It is produced through a process called transesterification, where oils are reacted with an alcohol (usually methanol) to form biodiesel and glycerin.
- Biodiesel (produced from vegetable oils or animal fats via transesterification).
- Bioethanol (produced by fermenting sugars from crops like sugarcane or corn).
- Bioethanol is ethanol (ethyl alcohol) produced from fermenting the sugars found in crops like sugarcane, corn, or other starch-rich plants.
- Syngas (a mixture of CO and H2) is typically produced from gasification of coal or natural gas, not exclusively from biomass, though "biosyngas" is a term used when biomass is the feedstock.
- Syngas (synthetic gas) is a mixture of hydrogen, carbon monoxide, and carbon dioxide, produced by gasifying biomass, coal, or other carbon-containing materials.
- Natural Gas is a fossil fuel formed from ancient organic matter over millions of years and is not considered a biofuel.
- Biogas primarily composed of methane and carbon dioxide, produced by anaerobic digestion of organic waste.
- Biogas is a type of biofuel produced through the anaerobic digestion of organic matter, such as agricultural waste, manure, sewage, and food scraps.
- Biodiesel: A diesel-equivalent, processed fuel derived from biological sources (e.g., Jatropha, soybean oil).

Additional Knowledge:
- Natural Gas: A fossil fuel consisting mainly of methane, formed from decomposed organisms over geological time scales.
- Natural gas is not considered a biofuel because it is not derived from biological sources, but rather from geological deposits of organic materials.

Q11. Consider the following statements about Gas Chromatography (GC)
A. In GC, the stationary phase is a liquid adsorbed on an inert solid support or a bonded phase, and the mobile phase is an inert gas.
B. In GC, compounds with lower boiling points typically elute later than compounds with higher boiling points, assuming similar chemical characteristics.
C. Increasing the column temperature in GC generally decreases the retention time of analytes.
D. Flame Ionization Detectors (FIDs) are universally destructive and respond to nearly all organic compounds.

E. The choice of carrier gas (mobile phase) significantly affects the separation efficiency and analysis time in GC.

Choose the correct answer from the options given below:

(A). A, C, and D Only

(B). A, B, C, and E Only

(C). A, C, D, and E Only

(D). B, C, and E Only

Answer: c

Solution:

Introduction:

- Gas Chromatography (GC) is a powerful analytical technique used to separate, identify, and quantify chemical compounds in a sample.
- It is commonly employed in various fields such as chemistry, biochemistry, environmental science, forensic analysis, and pharmaceuticals.
- GC is particularly useful for analyzing volatile substances that can easily be vaporized without decomposition.

Information Booster:

- In Gas Chromatography, the stationary phase can indeed be a liquid that is either adsorbed onto an inert solid support or bonded to the surface of the solid.
- The mobile phase is always an inert gas, such as helium or nitrogen, which carries the analytes through the column.
- Increasing the column temperature in GC decreases the retention time of analytes because higher temperatures reduce the interaction between the analytes and the stationary phase.
- As a result, compounds move faster through the column, eluting more quickly.
- FID is a destructive detector because it burns the analyte in a flame, ionizing it and detecting the resulting ions.
- FIDs respond to almost all organic compounds that can be combusted, making it one of the most commonly used detectors in GC.
- The carrier gas (usually helium, hydrogen, or nitrogen) can influence the separation efficiency and analysis time.
- For example, helium is often preferred because it provides fast separation with good resolution, while hydrogen is faster but potentially more dangerous.
- The flow rate and type of carrier gas can affect the peak shapes, separation efficiency, and analysis time.

Additional knowledge:

- In GC, compounds with lower boiling points tend to elute earlier than those with higher boiling points, assuming similar chemical characteristics.
- This is because compounds with lower boiling points have a higher vapor pressure, making them more volatile and thus they travel faster through the column.

Q12. Which of the following pairs of heavy metals and their primary toxic effects on human health is/are correctly matched?

A. Mercury : Minamata disease
B. Cadmium : Itai-Itai disease
C. Lead : Blue Baby Syndrome
D. Arsenic : Blackfoot disease
E. Chromium (VI) : Severe respiratory and neurological damage
Choose the correct answer from the options given below:
(A). A, B and C Only
(B). A, B and D Only
(C). B, C and E Only
(D). C, D and E Only
Answer: b
Solution:

Introduction:

- The understanding of classic, historically significant diseases and conditions caused by specific heavy metal toxicities.
- Correctly pairing the pollutant with its most infamous health impact is fundamental to environmental toxicology.
- While all the listed metals are highly toxic, their mechanisms and signature effects differ significantl.
- It also represent common misconceptions or incorrect pairings that are crucial to identify for a clear understanding.

Information Booster:

- Mercury & Minamata Disease: Minamata disease is a neurological syndrome caused by severe mercury poisoning, specifically methylmercury.
- It is characterized by ataxia, numbness, muscle weakness, and vision and hearing loss, first identified in Minamata Bay, Japan, due to industrial wastewater.
- Cadmium & Itai-Itai Disease: Itai-Itai disease (translated as "it hurts, it hurts") was a mass cadmium poisoning event in Japan.
- Cadmium contamination of rice fields led to renal tubular dysfunction and severe osteomalacia (softening of the bones), causing extreme pain and multiple fractures.
- Arsenic & Blackfoot Disease: Chronic arsenic poisoning from contaminated drinking water is a major cause of Blackfoot disease, a severe form of peripheral vascular disease
- It leads to gangrene and spontaneous amputations, notably documented in Taiwan.

Additional knowledge:

- Lead & Blue Baby Syndrome: Blue Baby Syndrome (Methemoglobinemia) is primarily caused by high nitrate levels in drinking water, which oxidizes hemoglobin to methemoglobin.
- Lead poisoning primarily causes anemia, neurodevelopmental defects in children, and damage to the nervous system and kidneys.
- Chromium (VI) & Severe respiratory and neurological damage:While Chromium (VI) is a potent carcinogen and causes severe respiratory issues (asthma, nasal ulcers, lung cancer).
- Its primary toxicological signature is not neurological damage.
- Neurological damage is more characteristic of mercury and lead poisoning.

Q13. Which of the following organochlorine compounds is an analog DDT (Dichlorodiphenyltrichloroethane) and was primarily developed to retain DDT's broad-spectrum insecticidal activity while possessing higher biodegradability and significantly lower environmental persistence and bioaccumulation potential?

(A). DDA (Bis(4-chlorophenyl)acetic acid)

(B). Methoxychlor (1,1,1-Trichloro-2,2-bis(p-methoxyphenyl)ethane)

(C). Lindane (Gamma-hexachlorocyclohexane)

(D). Dicofol (1,1,1-Trichloro-2,2-bis(4-chlorophenyl)ethanol)

Answer: b

Solution:

Introduction:

- Pesticide chemistry often behaves like a long family tree once a compound proves powerful, researchers start tweaking its structure to keep the usefulness while trimming the environmental baggage.
- DDT inspired exactly this kind of chemical tinkering.

Information Booster:

- Methoxychlor is the most important analog of DDT developed to improve its environmental profile.
- It shares the same basic diphenylmethane skeleton and insecticidal mode of action (disrupting nerve signal transmission).
- This methoxy group substitution makes methoxychlor significantly more susceptible to enzymatic and oxidative degradation in the environment and in animal tissues.
- It results in a much shorter half-life and lower bioaccumulation potential compared to DDT.
- Methoxychlor is essentially DDT with methoxy groups replacing chlorine atoms on the aromatic rings. Those substitutions make it:
- More biodegradable (microbes can break methoxy-substituted rings more easily)
- Far less bioaccumulative
- Less persistent in soil and tissues

Additional knowledge:

- DDA: This is an important metabolite of DDT (formed after degradation), not a commercially successful analog used as a pesticide.
- Lindane: This is a gamma-isomer of HCH (Hexachlorocyclohexane) and is an organochlorine pesticide, but it has a different chemical structure (a cyclized ring) and mode of action than DDT.
- Dicofol: This is a derivative of DDT often used as a miticide (mite killer), but it is structurally different (having an hydroxyl (OH) group instead of a trichloro group) and is not generally cited as the primary biodegradable analog.

Q14. In a standard Linear Regression model used to assess the relationship between pollutant concentration (Y) and source distance (X), which assumption relates directly to the variability of prediction errors across all values of X?

(A). Normality of residuals

(B). Homoscedasticity

(C). Independence of observations

(D). Linearity of relationship
Answer: b
Solution:
Introduction:

- Regression analysis, used widely in environmental modeling, relies on several key assumptions about the data and the error term (residuals) to ensure the estimates are unbiased and reliable.

Information Booster:

- Homoscedasticity: This assumption states that the variance (or scatter) of the residuals (prediction errors) must be constant across all levels of the independent variable (X).
- Violation (Heteroscedasticity): If the variance increases as X increases (e.g., pollutant measurement errors are larger further from the source), the assumption is violated, leading to inaccurate standard errors and poor confidence intervals.
- Normality of residuals: Assumes the errors follow a Normal Distribution19, which is important for hypothesis testing and setting confidence limits.
- Linear Regression relies on several key assumptions to ensure that the estimates (coefficients) are unbiased and that the standard errors and hypothesis tests are valid.
- These assumptions primarily concern the properties of the residuals (or prediction errors), which are the differences between the observed values of the dependent variable (Y) and the values predicted by the model (Y^).
- For assessing the strength of the relationship between a binary outcome, the Relative Risk (RR) or Odds Ratio (OR) is used in epidemiology20.
- The Cohen's Kappa statistic measures agreement between two categorical variables, not quantitative ones.
- Environmental Context Example
- In your example:
- Y = Pollutant Concentration
- X = Source Distance
- Homoscedasticity assumes that the error in predicting the pollutant concentration is the same whether you are measuring very close to the source or very far from the source
- The Violation: Heteroscedasticity
- If the assumption of homoscedasticity is violated, the condition is called Heteroscedasticity (hetero meaning "different").[10]
- **Additional knowledge:**
- Normality of Residuals : Assumes that the residuals (the prediction errors) are normally distributed (bell curve) around a mean of zero.
- This assumption relates to the shape of the error distribution, not specifically how the variability (spread) of those errors changes across different values of X.
- Independence of Observations (No Autocorrelation) : Assumes that the residuals are uncorrelated with each other. The error for one observation should not influence the error for another observation.
- This is critical in time-series or spatial data (like environmental sampling). It ensures that data points are independent, but it does not address the variability of errors with respect to the X value.

- Linearity of Relationship: Assumes that the relationship between X and the mean of Y is accurately described by a straight line.
- Why it's Incorrect: This is a fundamental structural assumption of the model itself. It is about the form of the relationship, not the variability of the errors around that relationship.

Q15. Consider the following statements regarding the validity and application of Darcy's Law in characterizing the flow of water and contaminants through porous media:
I. Darcy's Law is valid only for laminar flow conditions in the porous medium, a condition typically met when the Reynolds Number for the flow is significantly less than1(Re≪1
II. The Hydraulic Conductivity (K) factor is solely a function of the properties of the porous medium (e.g., grain size, sorting) and is independent of the fluid properties (e.g., viscosity, density).
III. For flow in the unsaturated zone, Darcy's Law is modified into the Richards Equation by making the hydraulic conductivity (K) a variable function of the moisture content θ
IV. In a homogeneous, isotropic aquifer, the flow velocity calculated using Darcy's Law represents the average linear velocity (or seepage velocity) of the water, which is faster than the measured Darcy Flux q
Which of the statements given above is/are correct?
(A). I and II only
(B). II and IV only
(C). I, III, and IV only
(D). I, II, III, and IV
Answer: c
Solution:
Introduction:

- **Darcy's Law** is the foundational principle of hydrogeology and groundwater flow.
- It linearly relates the volumetric flow rate (Q) to the hydraulic gradient (Δh/L\Delta h / LΔh/L) and the cross-sectional area (A), using a proportionality constant known as hydraulic conductivity (K).
- Understanding its limitations and the definitions of its parameters is essential for advanced environmental studies.

Information Booster:

- Darcy's Law is strictly an empirical observation that holds true only for laminar flow.
- Laminar flow occurs when the viscous forces dominate inertial forces, which, for flow through porous media, corresponds to a Reynolds Number (Re) less than approximately 1 or 10. Turbulent flow invalidates the law.
- In the unsaturated zone (vadose zone), where pores contain both air and water, the hydraulic conductivity (K) is strongly dependent on how saturated the pores are.
- The Richards Equation is the governing equation for unsaturated flow, derived by applying Darcy's Law and making K a variable function of the volumetric moisture content θ
- The Darcy Flux (q = Q/A**)** is the apparent velocity calculated by the law.
- The average linear velocity (va), or seepage velocity, is the actual speed of water movement, which is calculated as va=q/ne (where ne is effective porosity). Since porosity (ne) is always less than 1, the actual velocity (va) is always **greater** than the Darcy Flux (q).

Additional Knowledge:

- **Hydraulic Conductivity (K)** is not solely a property of the porous medium. It is a combined property: K=k·(ρg/μ) where k is the Intrinsic Permeability (property of the medium only),ρ \rhoρ is the fluid density, g is gravity, and μ\mu is the fluid viscosity.
- Since viscosity (μ\mu and density (ρ\rho) are properties of the fluid (e.g., they change with temperature or dissolved solids), K is dependent on the fluid properties.

Q16. Arrange the following stages of ecological succession (Seral Stages) in the sequential order of their typical appearance during the development of a Terrestrial Climax Community.
(A) Shrub and Shade-Intolerant Tree Stage
(B) Pioneer/Herbaceous Stage (e.g., Grasses, Annuals)
(C) Shade-Tolerant, Climax Forest Stage
(D) Intermediate/Small Tree Stage
(E) Bare Substrate (Unoccupied Land/Primary Stage)
Choose the correct answer from the options given below:
(A). (E), (B), (D), (A), (C)
(B). (E), (B), (A), (D), (C)
(C). (B), (E), (A), (D), (C)
(D). (B), (A), (D), (C), (E)
Answer: b
Solution:
Introduction:

- This question addresses Ecological Succession, the directional and predictable process of change in the species structure of an ecological community over time.
- The sequence of stages (seral stages) leads toward a stable, mature, and self-perpetuating Climax Community.
- The order of these stages is determined by species interactions and the progressive modification of the environment by the organisms themselves.

Information Booster:

- The correct sequential order of the stages, from bare ground to climax, is:
- Bare Substrate (Primary Stage): The starting point, which is rock, sand, or lava completely devoid of soil and life.
- This is the onset of Primary Succession.
- Pioneer/Herbaceous Stage: The first colonizers, often r-selected species (annuals, mosses, lichens, grasses) that can tolerate harsh conditions, fix nitrogen, and begin to break down rock to form rudimentary soil.
- Shrub and Shade-Intolerant Tree Stage: As the soil deepens, shrubs and fast-growing, sun-loving (shade-intolerant) small trees (e.g., pioneer trees like aspens or pines) move in and outcompete the herbaceous species.
- Intermediate/Small Tree Stage: These species grow taller, eventually shading out the earlier shrubs and creating a less harsh, more humid microclimate.

- Shade-Tolerant, Climax Forest Stage: The final, relatively stable community, characterized by slow-growing, long-lived, shade-tolerant trees (e.g., oaks, maples) that can successfully reproduce under their own canopy.
- This stage persists until a major disturbance resets the process.

Q17. In a stratified, eutrophic lake, the hypolimnion often becomes a distinct zone characterized by anoxia, the accumulation of hydrogen sulfide, and a community dominated by anaerobic decomposers. This zone, which is defined by the consistent condition where community respiration (R) far exceeds primary production (P) due to the complete absence of light, is most accurately termed the:
(A). Aphotic Zone
(B). Profundal zone
(C). Benthic Zone
(D). Limnetic Zone
Answer: b
Solution:
Introduction:
- In a **stratified, eutrophic lake**, the water column is divided into different layers based on temperature, light availability, and biological activity.
- The zone described in the question, characterized by **anoxia** (lack of oxygen), the accumulation of **hydrogen sulfide**, and **anaerobic decomposers**, is most accurately referred to as the **Profundal Zone**.

Information Booster:
- The hypolimnion (the deep, colder layer of water) in a stratified lake can become anoxic, meaning it lacks oxygen.
- In eutrophic (nutrient-rich) lakes, this is particularly common because of decomposition of organic matter by anaerobic bacteria, which can produce hydrogen sulfide.
- In the absence of light and oxygen, the anaerobic decomposers (microorganisms that do not require oxygen to break down organic matter) dominate in this zone.
- They help break down dead organic material, producing gases like methane and hydrogen sulfide as byproducts.
- Since light does not reach the profundal zone (it's below the photic zone where photosynthesis occurs), primary production (P) is essentially nonexistent here.
- The community in the profundal zone relies on respiration (R) from decomposers breaking down organic material that has sunk from the upper layers, and this process far exceeds primary production because there's no sunlight for photosynthesis
- Aphotic Zone: This term refers to the dark zone of a body of water where no sunlight penetrates, but it does not specifically imply anoxic conditions or anaerobic decomposition.
- While the profundal zone is indeed aphotic, the aphotic zone itself is not necessarily anoxic or dominated by anaerobic decomposers. Therefore, it is a broader term and not the most accurate for this particular description.
- The benthic zone refers to the bottom of the lake or any water body, including the lakebed.

- While the benthic zone is indeed located in the same area as the profundal zone (at the bottom of the lake), it doesn't specifically describe the absence of light or the anoxic conditions of the deeper waters.
- The benthic zone is defined more by its location (lakebed) than by the specific oxygen conditions described in the question.

Additional knowledge:

- The limnetic zone refers to the open water area that is well-lit and supports photosynthesis. It is the uppermost layer of the lake where sunlight reaches, and therefore, primary production (P) is high. This is the opposite of the profundal zone, where light doesn't reach and primary production is absent.
- The Profundal Zone is the most accurate term for the area of a stratified, eutrophic lake where the hypolimnion is characterized by anoxia, the accumulation of hydrogen sulfide, and a community dominated by anaerobic decomposers. This zone is defined by the complete absence of light and a situation where community respiration (R) far exceeds primary production (P).

Q18. Consider the following statements regarding Ocean Thermal Energy Conversion (OTEC):
A. OTEC systems typically exploit the temperature difference between warm surface waters and cold deep waters.
B. Closed-cycle OTEC uses ammonia or a similar working fluid with a low boiling point.
C. Open-cycle OTEC produces desalinated water as a by-product.
D. Hybrid OTEC systems combine features of both closed-cycle and open-cycle systems.
E. The efficiency of OTEC systems is generally high due to the large temperature differential available in tropical oceans.
Choose the correct answer from the options given below:
(A). A, B, C and D Only
(B). A, C, D and E Only
(C). B, C, D and E Only
(D). A, B, C, D and E
Answer: a
Solution:

Introduction:

- Ocean Thermal Energy Conversion (OTEC) is a renewable energy technology that harnesses the temperature gradient in the ocean to generate electricity.
- This explores the fundamental principles and variations of OTEC systems, highlighting their operational mechanisms and potential by-products.

Information Booster:

- OTEC technology relies on the temperature difference between the warm surface waters of tropical oceans (heated by the sun) and the cold deep waters (originating from polar regions and sinking).
- For efficient operation, a minimum temperature difference of about 20°C (36°F) is required, which is typically found in equatorial regions.
- There are three main types of OTEC systems: closed-cycle, open-cycle, and hybrid. Closed-cycle OTEC uses a working fluid like ammonia, propane, or R-134a, which has a low boiling point.

- The warm surface water vaporizes the working fluid, driving a turbine, and then the cold deep water condenses the vapor back into a liquid, completing the cycle. Open-cycle OTEC directly uses the warm ocean water as the working fluid.
- It is flash-evaporated in a low-pressure vacuum chamber, producing low-pressure steam that drives a turbine.
- This steam is then condensed by cold deep water, yielding desalinated water as a valuable by-product.
- Hybrid systems combine aspects of both closed and open cycles to optimize energy production and by-product creation.
- While OTEC offers continuous, baseload power, its overall thermal efficiency is inherently low (typically 3-5%) due to the relatively small temperature differences exploited, requiring large volumes of water to generate significant power.

Additional Knowledge:

- The efficiency of OTEC systems is generally **low** (around 3-5%) due to the relatively small temperature difference available, not high.
- Even with optimal temperature differentials in tropical oceans, the Carnot efficiency limit for such a small temperature gradient is inherently low, necessitating large-scale infrastructure to produce commercially viable amounts of power.

Q19. Match the following elements with their dominant occurrence in the Earth's layers.

LIST-I (Element)	LIST-II (Earth's Layer)
A. Iron (Fe)	I. Continental Crust
B. Oxygen (O)	II. Core
C. Silicon (Si)	III. Oceanic Crust
D. Magnesium (Mg)	IV. Mantle

Choose the correct answer from the options given below:

(A). A-II, B-I, C-III, D-IV

(B). A-I, B-II, C-IV, D-III

(C). A-II, B-IV, C-I, D-III

(D). A-IV, B-III, C-II, D-I

Answer: c

Solution:

Introduction:

- The **oceanic crust** is the part of Earth's outer shell that forms the ocean floors.
- It is made up primarily of **basalt**, a dark, dense volcanic rock that is rich in iron and magnesium.
- The oceanic crust is thinner, denser, and younger compared to the **continental crust**, which forms the landmasses.

Information Booster:

- Iron (Fe) = Core
- Oxygen (O) = Entire Crust
- Magnesium (Mg) = Entire Crust
- Nickel (Ni) = Oceanic Crust

- Iron (Fe) is the primary constituent of Earth's Core, along with nickel.
- Oxygen (O) is the most abundant element by volume in the Entire Crust, as it is a major component of most minerals (silicates, oxides).
- Magnesium (Mg) is a key element in mantle minerals like olivine [$(Mg,Fe)_2SiO_4$] and pyroxene, making it dominant in the Mantle.
- Nickel (Ni) is a significant alloying element with iron in the Core.

Additional Knowledge:

- Oceanic crust (mafic: rich in Mg and Fe) is richer in Magnesium compared to continental crust (felsic: rich in Si, Al, O, Na, K).
- The bulk composition of Earth's layers varies significantly. The core is metallic, while the crust and mantle are silicate-rich.

Q20. Arrange the following stages in the anaerobic decomposition of food waste in a landfill in the correct chronological sequence.

A. Acetogenesis
B. Hydrolysis
C. Methanogenesis
D. Acidogenesis
E. Landfill Gas Production (CO_2 & CH_4)

Choose the correct answer from the options given below:

(A). B, A, D, C, E
(B). D, B, A, C, E
(C). B, D, A, C, E
(D). A, B, D, C, E

Answer: c

Solution:

Introduction:

- Hydrolysis (breakdown of complex organic materials into simpler molecules)
- Acidogenesis (further breakdown into volatile fatty acids and other by-products)
- Acetogenesis (conversion of acids into acetic acid and hydrogen)
- Methanogenesis (conversion of acetic acid and hydrogen into methane)
- Landfill gas production (CO_2 and CH_4 are the final gases produced)

Information Booster:

- The anaerobic decomposition of food waste in a landfill occurs in several stages, each facilitated by different groups of microorganisms. Here's a breakdown of each stage and its correct sequence:
- Hydrolysis is the first step in the anaerobic decomposition process.
- During this stage, complex organic materials (like carbohydrates, proteins, and fats) are broken down into simpler molecules (such as sugars, amino acids, and fatty acids) by hydrolytic bacteria.
- This makes the organic matter more accessible for further microbial activity.
- In acidogenesis, the simpler molecules produced during hydrolysis are further broken down by acidogenic bacteria.

- These bacteria convert sugars and amino acids into volatile fatty acids (VFAs), hydrogen, and carbon dioxide.
- This stage produces acids that lower the pH of the landfill environment.
- In the acetogenesis stage, acetogenic bacteria convert the products of acidogenesis (such as volatile fatty acids) into acetic acid and hydrogen gas.
- Acetogenesis is important because it produces compounds that are critical for the methanogenesis phase.
- Methanogenesis is carried out by methanogenic archaea.
- These microorganisms convert acetic acid, hydrogen, and carbon dioxide into methane (CH_4) and carbon dioxide (CO_2).
- This stage is crucial for the production of methane, which is a key component of landfill gas.
- The final stage of anaerobic decomposition is the production of landfill gas, which primarily consists of methane (CH_4) and carbon dioxide (CO_2).
- The methane produced during methanogenesis is an important greenhouse gas and can also be captured and used for energy production.

Q21. Choose the INCORRECT statement about High-Performance Liquid Chromatography (HPLC).

(A). HPLC is used for the separation of non-volatile, thermally unstable, and high molecular weight compounds.

(B). The stationary phase is typically a solid adsorbent, and the mobile phase is a liquid solvent.

(C). A UV-Vis detector is a common, non-destructive detector used in HPLC

(D). Reverse-phase HPLC uses a polar stationary phase and a non-polar mobile phase.

Answer: d

Solution:

Introduction:

- In **Reverse-phase HPLC** (RP-HPLC), the **stationary phase is non-polar**, not polar.
- HPLC is particularly useful for separating compounds that are **non-volatile** or **thermally unstable**, which cannot be analyzed using gas chromatography (GC).
- It is also used for high-molecular-weight compounds, such as proteins or polymers.

Information Booster:

- In HPLC, the stationary phase is typically a solid adsorbent, which could be silica gel or other materials, and the **mobile phase** is a liquid solvent that moves through the stationary phase, carrying the sample components.
- A **UV-Vis detector** is indeed a common **non-destructive** detector in HPLC.
- It detects the absorbance of light by compounds in the sample, especially those that absorb ultraviolet or visible light, without altering the compounds being measured.
- In **reverse-phase HPLC**, the **stationary phase is non-polar** (usually a C18 bonded phase, which is a long hydrocarbon chain) and the **mobile phase is polar** (usually a mixture of water and organic solvents like methanol or acetonitrile).
- The non-polar stationary phase interacts more strongly with non-polar compounds, while polar compounds will elute faster with the mobile phase.

- In reverse-phase HPLC, the non-polar stationary phase has stronger interactions with hydrophobic (non-polar) compounds, causing them to move more slowly through the column.

Additional knowledge:

- Polar compounds interact less with the stationary phase and elute faster with the mobile phase.
- This makes reverse-phase HPLC particularly effective for separating a wide range of compounds, especially organic molecules.
- Reverse-phase HPLC uses a polar stationary phase and a non-polar mobile phase is not correct because, in reverse-phase HPLC, the stationary phase is non-polar, and the mobile phase is polar.

Q22. Arrange the following stages of an Ecological Impact Assessment (EIA) in their standard chronological sequence.

A. Impact Prediction and Evaluation
B. Screening
C. Mitigation and Impact Management
D. Scoping
E. Public Hearing and Decision Making

Choose the correct answer from the options given below:

(A). B, D, A, C, E
(B). D, B, A, C, E
(C). B, A, D, E, C
(D). A, B, D, C, E

Answer: a

Solution:

Introduction:

- The EIA process is a sequential, iterative process designed to be systematic.
- It begins with Screening to determine if a project requires a full EIA. Next is Scoping, which identifies the key issues and impacts.
- This is followed by the detailed Impact Prediction and Evaluation.
- Based on the predicted impacts, Mitigation and Impact Management measures are proposed to avoid, reduce, or compensate for the impacts.
- The process culminates in a Public Hearing and the regulatory authority's Decision Making on whether to grant environmental clearance.

Information Booster:

- Screening: It decides if an EIA is needed based on project type and scale.
- Scoping: Identifies the spatial and temporal boundaries of the study and the key environmental components to be assessed.
- Impact Prediction: The technical core of the EIA, forecasting the magnitude and significance of potential impacts.
- Mitigation: Proposing measures to make the project environmentally acceptable.
- Decision Making: The final stage where the EIA report is reviewed, public input is considered, and a decision is made.

Additional Knowledge:

- Baseline Data Collection is a part of the scoping and impact prediction phases.
- Post-Monitoring is a crucial step after project approval to ensure compliance with mitigation measures.
- In India, the process is governed by the Environmental Protection Act, 1986, and EIA Notification, 2006.

Q23. Which of the following committees are correctly matched with their roles in the environmental clearance process for Category A and Category B projects?

A. Expert Appraisal Committee (EAC): Grants final environmental clearance for all Category B projects.

B. State Level Expert Appraisal Committee (SEAC): Screens and categorizes projects for State-level clearance.

C. State Level Expert Appraisal Committee (SEAC): Appraises Category B1 projects and recommends clearance to the SEIAA.

D. Expert Appraisal Committee (EAC): Appraises Category A projects and recommends clearance to the MoEF&CC.

Choose the correct answer from the options given below:

(A). A and B Only

(B). B and C Only

(C). B, C and D Only

(D). A, C and D Only

Answer: c

Solution:

Introduction:

- The Environmental Impact Assessment (EIA) Notification, 2006 (and its subsequent amendments) issued under the Environment (Protection) Act, 1986 lays down the procedure for environmental clearance of developmental projects in India.
- According to the Notification, projects are divided into two broad categories:
- Category A projects: Appraised at the Central level by the Expert Appraisal Committee (EAC) under the Ministry of Environment, Forest and Climate Change (MoEF&CC).
- Category B projects: Appraised at the State level by the State Level Expert Appraisal Committee (SEAC) and decided by the State Environment Impact Assessment Authority (SEIAA).

Information Booster:

- SEAC: Screens and categorizes projects under Category B into B1 (requiring EIA) and B2 (no EIA required) — a key role in the early stages of state-level clearance.
- SEAC: Appraises Category B1 projects (those needing full EIA) and submits its recommendations to the State Environmental Impact Assessment Authority (SEIAA) for final clearance.
- EAC: Responsible for Category A project appraisal and makes recommendations to the MoEF&CC, which is the final authority to grant environmental clearance.
- Expert Appraisal Committee (EAC): Constituted by MoEF&CC at the national level.
- Sector-specific EACs exist (e.g., mining, industry, infrastructure).
- Functions: Scoping, Appraisal, and Recommendation for Category A projects.

- Screens, categorizes, and appraises Category B projects.
- For Category B1 projects → recommends to SEIAA after appraisal.
- For Category B2 projects → directly submits simplified environmental information for decision-making.
- State Environmental Impact Assessment Authority (SEIAA):
- Headed by the State Secretary (Environment or Forest).

Additional Knowledge:

- EAC (Category A): Appraises the environmental impacts of Category A projects and makes recommendations to MoEF&CC for granting or rejecting clearance. It does not directly grant clearance.
- EAC & Category B: EAC is exclusively for Category A projects.

Q24. The Lotka-Volterra competition model for two species (N1andN2) incorporates two parameters, α12andα21 , which represent the competition coefficients. What is the ecological interpretation of the condition where α12>1.?

(A). Species N1N_1N1 has a greater negative impact on the growth rate of species N2N_2N2 than an individual of N2 has on its own growth rate.

(B). An individual of species N2 consumes resources or inhibits the growth of species N1N_1N1 more strongly than an individual of N1 inhibits its own growth.

(C). The interspecific competition is weaker than the intraspecific competition for both species, leading to coexistence.

(D). Species N2 is competitively excluded by species N1.

Answer: b

Solution:

Introduction:

- The Lotka-Volterra competition model mathematically represents interspecific competition, using competition coefficients (α\alphaα) to relate the impact of one species on another.

Information Booster

- The competition coefficient alphaij quantifies the inhibitory effect of an individual of species jjj on the growth rate of speciesi ii, relative to the inhibitory effect of an individual of species i on its own growth (αii,whichisassumedtobe1). Ifα12>1
- It means that one individual of species N2N_2N2(the competitor) inhibits the population growth rate of species N1N_1N1 (the focal species) more effectively than one individual of speciesN1 N_1N1 inhibits the population growth rate of N1N_1N1 itself (intraspecific competition).
- This is a condition of strong interspecific competition.
- $\alpha_{21} > 1$
- Species N_1 normally slows its own growth as its population rises that's standard intraspecific competition.
- But if one individual of species N_2 suppresses N_1 even more strongly, then N_2 is a more powerful competitor than N_1 is to itself.
- It's like N_2 is exceptionally good at grabbing the resource first, or blocking access, or interfering with N_1's ability to survive or reproduce.
- This could happen if:

- N_2 uses the critical limiting resource more efficiently
- N_2 grows faster and shades or overcrowds N_1
- N_2 has a physiological or behavioral edge (e.g., allelopathy in plants)

Additional Knowledge:

- α_{21} converts one N_2 individual into its "equivalent pressure" on N_1.

When $\alpha_{21} > 1$, it's saying:

- One individual of N_2 creates more competitive stress on N_1 than N_1 creates on itself through crowding or resource use.
- The outcome of competition (coexistence or exclusion) is determined by comparing the competition coefficients with the ratios of the species' carrying capacities (K).
- $\boldsymbol{\alpha_{12}} < 1$ and $\alpha_{21} < 1$When each species competes more strongly with itself than with the other species, you get stable coexistence.
- Each species' interference with its competitor is milder than the pressure it experiences from its own population growth.
- $\boldsymbol{\alpha_{12} > 1}$
- Here, species N_1 acts as a stronger competitor against N_2 than N_2 does against itself.

Q25. Which of the following are features of an Aquiclude?

A. Impermeable Layer

B. Transmits Water

C. Blocks Groundwater Movement

D. Allows for Well Water Extraction

Choose the correct answer from the options given below:

(A). A and C Only

(B). B and D Only

(C). A and D Only

(D). A, C and D Only

Answer: a

Solution:

Introduction:

- An aquiclude is a geological formation that does not allow the movement of water.
- It is typically impermeable and blocks groundwater flow, preventing water from moving between aquifers.

Information Booster:

- Impermeable Layer: Aquicludes are made of impermeable rock or clay that does not transmit water.
- Blocks Groundwater Movement: Prevents the vertical or lateral flow of groundwater.
- The presence of aquicludes influences the development of various landforms and groundwater systems.
- Aquicludes confine water within an aquifer, creating what is called a **confined aquifer**.
- Aquicludes are often made of materials like **clay, shale, or dense rock** that have very low permeability.

Additional Knowledge:

- Transmits Water: This feature is more characteristic of aquifers, not aquicludes.
- Allows for Well Water Extraction: Aquicludes do not allow for water extraction due to their impermeability.

Q26. Match List - I with List - II regarding soil orders and their distinguishing properties:

List - I (Soil Order)	List - II (Major Property/Setting)
(A) Histosols	I. High content of expanding 2:1 lattice clays (swelling/shrinking)
(B) Vertisols	II. Characterized by high organic matter content (peat or muck)
(C) Oxisols	III. Very young soils with little to no horizon development
(D) Entisols	IV. Highly weathered tropical soils, rich in Fe and Al oxides

Choose the correct answer from the options given below:
(A). (A)-II, (B)-I, (C)-IV, (D)-III
(B). (A)-III, (B)-IV, (C)-I, (D)-II
(C). (A)-II, (B)-III, (C)-IV, (D)-I
(D). (A)-I, (B)-II, (C)-III, (D)-IV
Answer: a
Solution:
Introduction:
- Soil classification is primarily based on diagnostic horizons specific layers within the soil profile that have unique physical, chemical, and biological properties.
- The relationship between these horizons and the broader Soil Orders is essential for determining land use capability and environmental management strategies.

Information Booster:
- Histosols: These soils are defined by a high concentration of organic matter in the upper layers, often forming in wetlands where anaerobic conditions slow decomposition.
- They frequently contain the Mollic horizon (thick, dark, high base saturation) seen in your reference images.
- Vertisols : These soils contain a high percentage of "smectite" clays.
- When wet, they swell, and when dry, they shrink, creating large deep cracks. This physical movement often prevents distinct horizon development.
- Oxisols : These represent the most highly weathered stage of soil development, typically found in humid tropical regions.
- They are characterized by an accumulation of iron (Fe) and aluminum (Al) oxides and low activity clays, similar to the Kandic and Spodic features.
- Entisols : These are soils that lack diagnostic horizons, usually because they are too young or are located on rapidly eroding slopes or active floodplains where new material is constantly deposited.

Q27. Consider the following isotopes found in the decay chain of Uranium-238:
A) Thorium-234 (Half-life: 24 days)
B) Protactinium-234 (Half-life: 6.7 hours)
C) Uranium-234 (Half-life: 245,000 years)
D) Radium-226 (Half-life: 1600 years)

In a sealed sample of pure Uranium-238 that has reached secular equilibrium, which of the following correctly represents the order of molar concentration from lowest to highest?

(A). (B), (A), (D), (C)

(B). (A), (B), (C), (D)

(C). (B), (D), (A), (C)

(D). (C), (D), (A), (B)

Answer: a

Solution:

Introduction:

- In a secular equilibrium (also known as radioactive equilibrium) situation, the isotopes in the decay chain reach a state where the decay rate of each isotope equals the production rate of the next isotope in the chain.
- This means that the amount of each isotope remains approximately constant over time, but the concentration of isotopes varies based on their half-lives.
- The general rule is that isotopes with shorter half-lives will be present in higher concentrations because they decay more quickly, while isotopes with longer half-lives will be present in lower concentration**s**.

Information Booster:

- Protactinium-234 (Pa-234): Shortest half-life, high concentration.
- Thorium-234 (Th-234): Short half-life, high concentration.
- Radium-226 (Ra-226): Longer half-life than Th-234, moderate concentration.
- Uranium-234 (U-234): Longest half-life, lowest concentration.
- U-238 is the parent isotope and is at the top of the decay chain.
- Th-234 decays relatively quickly, it will have a higher molar concentration than the longer-lived isotopes further down the chain.
- Pa-234 decays even faster than Th-234. Because it has such a short half-life, its molar concentration will be lower than that of Th-234, but still higher than the longer-lived isotopes.
- U-234 has the longest half-life of the isotopes listed here, so its molar concentration in secular equilibrium will be lowest.
- This is because the parent isotope (U-238) produces U-234, but it has a much slower decay rate, so U-234 will accumulate at a slower rate than the isotopes with shorter half-lives.
- Ra-226 decays more slowly than the other isotopes in the decay chain, but it is still much faster than U-234. So, its molar concentration will be higher than U-234 but lower than Th-234 and Pa-234.
- In secular equilibrium, the rate of decay of the parent isotope (U-238) is balanced by the rate of decay of the daughter isotopes.
- Daughter isotopes that have shorter half-lives will accumulate more quickly, while those with longer half-lives will accumulate more slowly.
- Thus, the molar concentration of the isotopes in the decay chain will be highest for the daughter with the shortest half-life and lowest for the daughter with the longest half-life.

Q28. Which of the following statements INCORRECTLY describe the function or placement of a key component within an environmental biosensor?

A. The Transducer Element is responsible for converting a measurable physicochemical change (e.g., mass, pH, heat) into a quantifiable electrical signal.

B. Enzymes are often used as the Recognition Element because of their high catalytic efficiency and broad spectrum of reactivity toward various pollutants.

C. In an Amperometric Biosensor, the conversion of the biochemical event into an electrical current change primarily occurs at the Electrical Interface.

D. The Recognition Element is positioned closest to the sample, where it selectively interacts with the target analyte.

E. A Whole Bacterial Cell acts as the transducer in a toxicity biosensor, reporting changes in metabolic rate directly as a voltage.

Choose the correct answer from the options given below:

(A). A and C Only

(B). B and E Only

(C). C and D Only

(D). A and B Only

Answer: b

Solution:

Introduction:

- Environmental biosensors have two core functional blocks: a Recognition Element (bio-receptor) that selectively interacts with the analyte, and a Transducer / Electrical Interface that converts that biochemical interaction into a measurable electrical signal.
- Common recognition elements include enzymes, antibodies, nucleic acids, whole cells, and molecularly imprinted polymers.
- Transduction modes include amperometric (current), potentiometric (voltage), conductometric (resistance), piezoelectric (mass), and optical methods.

Information Booster:

- The transducer is literally the device/component that converts e.g., a mass change (QCM), pH change (field-effect transistor or ion-selective electrode), heat (thermopile), or redox chemistry (electrode) into an electrical quantity (current, voltage, frequency shift).
- Examples: electrodes (amperometric/potentiometric), piezoelectric crystals, optical fibers with fluorescence readout.
- So it describes transducer function.
- Amperometric biosensor → biochemical event → electrical current at electrical interface.
- In amperometric sensors the biochemical reaction produces or consumes electroactive species (e.g., H_2O_2, NADH) that are oxidized/reduced at an electrode, producing a current proportional to analyte concentration.
- The electrode / electrical interface is indeed the site where the electrochemical conversion and measurement occur.

Recognition element positioned closest to sample to selectively interact with analyte.

- The recognition element (enzyme, antibody, aptamer, cell) is immobilized on or near the sensing surface to ensure rapid and selective interaction with the target.
- Immobilization chemistries (crosslinking, entrapment, SAMs) place the bio-receptor at the interface between sample and transducer.

Additional knowledge:

- Whole cells can serve as recognition elements (they respond to toxicants by altered metabolism, respiration, membrane potential).
- However, they are not by themselves the transducer. A separate transducer converts the cell's biological change (metabolic rate, respiration, fluorescence, impedance) into an electrical/optical readout.
- Example: microbial fuel cell sensors use bacteria to generate current but here bacteria catalyze electron transfer to an anode (so bacteria participate in the transduction mechanism).
- Yet the electrode is still the transducer and the electrical signal is produced by an electrochemical interface engineered to harvest electrons. Saying the cell reports directly as a voltage oversimplifies and misattributes roles.
- Enzymes are indeed widely used as recognition elements because of high catalytic efficiency and ability to amplify signal via turnover.
- But enzymes are typically highly substrate-specific (narrow specificity), not broadly reactive.
- Their selectivity is a major advantage for targeted sensing (e.g., acetylcholinesterase inhibition by specific organophosphates), but a limitation when broad-spectrum detection is desired.
- For broad pollutant screening, whole-cell biosensors, enzyme panels, or non-biological receptors are preferred.

Q29. Which of the following statements regarding bioremediation are correct?

A. Bioremediation is a waste management technique that involves the use of organisms to remove or neutralize pollutants from a contaminated site.

B. Biostimulation involves adding nutrients or other substances to enhance the activity of existing microorganisms.

C. Bioaugmentation involves introducing specific microorganisms to a contaminated site to accelerate pollutant degradation.

D. Phytoremediation is a type of bioremediation that uses plants to remove, degrade, or contain contaminants.

E. Bioremediation is effective only for organic pollutants and cannot treat inorganic contaminants.

Choose the correct answer from the options given below:

(A). A, B, C and E Only

(B). B, C, D and E Only

(C). A, B, C and D Only

(D). A, C, D and E Only

Answer: c

Solution:

Introduction:

- Bioremediation is an environmentally friendly and cost-effective approach to clean up contaminated sites.
- It harnesses the natural metabolic capabilities of microorganisms, plants, or enzymes to transform harmful pollutants into less toxic or non-toxic forms.
- This process can occur naturally (intrinsic bioremediation) or be enhanced through various techniques.

Information Booster:

- Bioremediation is a waste management technique that involves the use of organisms to remove or neutralize pollutants from a contaminated site.
- Bioremediation leverages biological processes, primarily those of microorganisms, to break down, transform, or immobilize hazardous substances.
- Biostimulation involves adding nutrients or other substances to enhance the activity of existing microorganisms.
- Biostimulation often involves adding limiting nutrients like nitrogen and phosphorus, or electron acceptors like oxygen.
- Bioaugmentation involves introducing specific microorganisms to a contaminated site to accelerate pollutant degradation.
- Bioaugmentation is used when the native microbial population is insufficient or lacks the necessary metabolic pathways to degrade the target contaminants.
- It involves adding exogenous microorganisms with known degrading capabilities.
- Phytoremediation is a type of bioremediation that uses plants to remove, degrade, or contain contaminants.
- Phytoremediation utilizes various plant mechanisms, including phytoextraction, phytodegradation (enzymatic breakdown of contaminants by plants), rhizofiltration (absorption by roots in water).

Additional Knowledge:

- Bioremediation is effective only for organic pollutants and cannot treat inorganic contaminants.
- While bioremediation is highly effective for many organic pollutants (like hydrocarbons, pesticides, solvents), it can also be applied to inorganic contaminants.
- For example, some microorganisms can reduce toxic heavy metals (e.g., Cr(VI) to Cr(III), Hg(II) to Hg(0)) or alter their mobility and bioavailability, effectively treating them.

Q30. Match LIST-I with LIST-II.

LIST-I (Distribution)	LIST-II (Feature)
A. Log-normal	I. Arises from the sum of squared standard normal variables
B. F-distribution	II. Distribution of a sample mean with unknown variance
C. t-distribution	III. Ratio of two independent Chi-square variables
D. Chi-square distribution	IV. Variable whose logarithm is normally distributed

Choose the correct answer from the options given below:

(A). A - IV, B - III, C - II, D - I
(B). A - III, B - IV, C - I, D - II
(C). A - IV, B - I, C - II, D - III
(D). A - II, B - III, C - IV, D - I

Answer: a
Solution:
Introduction:
- Log-normal distribution corresponds to a variable whose logarithm follows a normal distribution.
- This distribution is skewed and commonly used to model environmental variables such as pollutant concentrations, rainfall intensity, and particle sizes.
- F-distribution is defined as the ratio of two independent Chi-square variables, each divided by their respective degrees of freedom.
- It is used in ANOVA, model comparisons, and variance ratio testing.
- t-distribution arises when estimating the mean of a normally distributed population with unknown variance, particularly for small sample sizes.
- It is symmetric like the normal distribution but with heavier tails.
- Chi-square distribution is generated from the sum of squares of independent standard normal variables, used in tests of independence, goodness of fit, and variance estimation.

Information Booster:
- Log-normal is highly right-skewed, making it suitable for environmental data that cannot take negative values.
- Chi-square distribution is non-negative, increasing its relevance in variance-related testing.t-distribution converges to normal distribution as sample size increases (df → ∞).
- F-distribution is always right-skewed, with shape depending on numerator and denominator degrees of freedom.
- Many environmental parameters show multiplicative variability, making log-normal a preferred model.
- ANOVA and regression analysis rely heavily on F-distribution for hypothesis testing.
- Chi-square tests are crucial in ecological studies for example, comparing species distribution patterns.

Q31. Consider an air parcel. Under which conditions will it be stable and resist vertical movement?
A. When the ELR is greater than the DALR.
B. When the ELR is less than the DALR.
C. When the ELR is equal to the SALR.
D. When the ELR is less than the SALR.
Choose the correct answer from the options given below:
(A). A and C Only
(B). B and D Only
(C). B and C Only
(D). A and D Only
Answer: b
Solution:
Introduction:
- The stability of an air parcel is determined by comparing the Environmental Lapse Rate (ELR) with the Adiabatic Lapse Rates (DALR and SALR).

- A parcel is stable if it is cooler (denser) than the surrounding air after being displaced, causing it to sink back to its original position.

Information Booster:

- If ELR < DALR, the environment cools slowly with height.
- A parcel rising adiabatically (at DALR, 10°C/km) will cool faster than its surroundings, become denser, and sink back down, indicating stability.
- The Saturated Adiabatic Lapse Rate (SALR ~5°C/km) is lower than DALR due to latent heat release.
- If ELR < SALR, the environment is very stable, as even a saturated parcel will be cooler than the surrounding environment at any lifted level.

Additional Knowledge:

- If ELR > DALR, the environment cools rapidly. A rising parcel will be warmer and less dense than its surroundings and will continue to rise, indicating **instability**.
- If ELR = SALR, the atmosphere is considered conditionally unstable, meaning stability depends on whether the air parcel is saturated or not.
- It is a neutral state for saturated air.