GATE Environmental Science and Engineering

Sample Paper – 9

Duration: 128 Minutes **Maximum Marks: 72**

Instructions

- This paper contains **46 questions** covering the core **Environmental Science and Engineering** subject of the GATE paper conducted by the IITs and IISc (General Aptitude and Engineering Mathematics are provided as separate papers).
- **Q1–Q20 carry 1 mark each** and **Q21–Q46 carry 2 marks each**, for a total of **72 marks**.
- Each question carries **negative marking of one-third of its allotted marks**: a wrong 1-mark question costs **0.33** and a wrong 2-mark question costs **0.67**. Unattempted questions carry no penalty.
- Every question here is a single-correct **MCQ**. The real GATE paper also has Multiple Select (MSQ) and Numerical Answer Type (NAT) questions, and **those carry no negative marking**.
- Attempt this paper in one timed sitting of about **128 minutes**, the share this core subject earns at GATE's overall pace of 180 minutes for 65 questions. Unless stated otherwise take $g = 9.81$ m/s^2, unit weight of water $\gamma_w = 9.81$ kN/m^3, dynamic viscosity of water $\mu = 1.0 \times 10^{-3}$ Pa·s and $K_w = 1.0 \times 10^{-14}$ at 25°C.

Environmental Chemistry and Microbiology

Q1. When chlorine gas is added to water it hydrolyses to hypochlorous acid, which partially dissociates as $HOCl \rightleftharpoons H^+ + OCl^-$. Among the free-chlorine species, the stronger disinfectant is: **[1 mark]**

(A) the chloride ion Cl^-

(B) the chlorate ion ClO_3^-

(C) hypochlorous acid HOCl

(D) the hypochlorite ion OCl^-

Q2. A water sample contains magnesium ions at a concentration of 24 mg/L (atomic mass of Mg $= 24$). Expressed as an equivalent concentration of calcium carbonate, the magnesium hardness is: **[1 mark]**

(A) 24 mg/L as $CaCO_3$

(B) 48 mg/L as $CaCO_3$

(C) 12 mg/L as $CaCO_3$

(D) 100 mg/L as $CaCO_3$

Q3. The formation of trihalomethanes (THMs), a group of chlorination disinfection by-products, in treated water results mainly from the reaction of chlorine with: **[1 mark]**

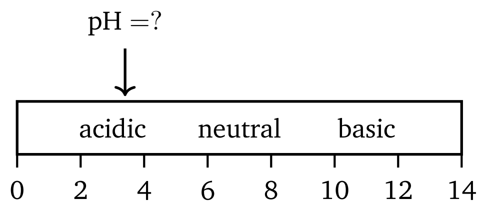
(A) dissolved oxygen

(B) natural organic matter (humic and fulvic acids)

(C) ammonia nitrogen

(D) calcium and magnesium ions

Q4. A water sample has a hydrogen-ion concentration $[H^+] = 4 \times 10^{-4}$ mol/L at 25°C. On the pH scale shown, its pH $= -\log_{10}[H^+]$ is nearest to: **[1 mark]**



(A) 3.4

(B) 4.0

(C) 10.6

(D) 7.0

Q5. When chlorine is applied to a water containing ammonia, part of the chlorine reacts with the ammonia. The combined chlorine residual formed in this reaction is present chiefly as: **[1 mark]**

(A) free chlorine gas Cl_2

(B) the chlorate ion ClO_3^-

(C) hypochlorous acid HOCl

(D) chloramines

Q6. The waterborne disease cholera, transmitted through faecally contaminated drinking water, is caused by: **[1 mark]**

(A) a protozoan parasite

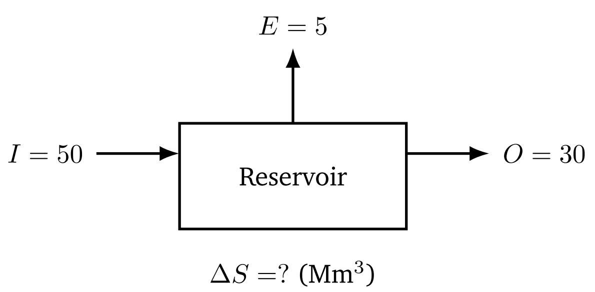
(B) a virus

(C) the bacterium *Vibrio cholerae*

(D) a parasitic helminth (worm)

Water Resources and Environmental Hydraulics

Q7. For the reservoir water balance shown over one month, the inflow is $I = 50$ Mm^3, the outflow is $O = 30$ Mm^3 and the evaporation loss is $E = 5$ Mm^3. By the storage equation $\Delta S = I - O - E$, the change in storage is: **[1 mark]**



(A) 85 Mm^3

(B) 20 Mm^3

(C) 5 Mm^3

(D) 15 Mm^3

Q8. Over a water year a catchment receives a rainfall depth of 30 cm and the observed direct-runoff depth is 12 cm. The runoff coefficient $C = \dfrac{\text{runoff}}{\text{rainfall}}$ of the catchment is: **[1 mark]**

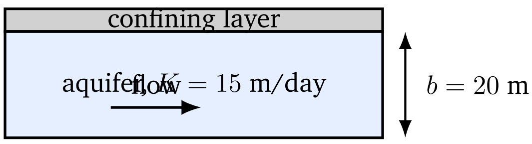
(A) 0.25

(B) 0.40

(C) 2.5

(D) 0.60

Q9. For the confined aquifer shown, the hydraulic conductivity is $K = 15$ m/day and the saturated thickness is $b = 20$ m. The transmissivity $T = K\,b$ of the aquifer is: **[1 mark]**



(A) 0.75 m^2/day

(B) 35 m^2/day

(C) 300 m^2/day

(D) 3000 m^2/day

Q10. In an aquifer the Darcy (specific-discharge) velocity is 0.6 m/day and the effective porosity is $n = 0.3$. The actual pore (seepage) velocity $v_s = \dfrac{v}{n}$ of the groundwater is: **[1 mark]**

(A) 0.18 m/day

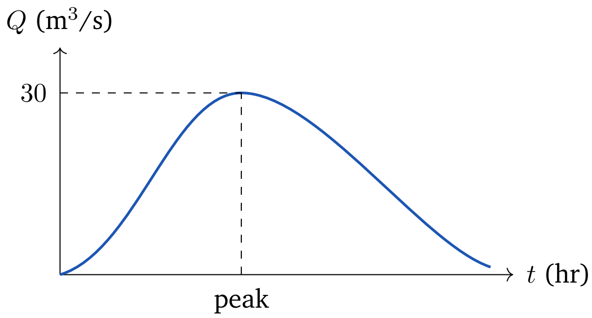
(B) 0.6 m/day

(C) 2.0 m/day

(D) 0.3 m/day

Q11. A 3-hour unit hydrograph of a catchment has a peak ordinate of 30 m^3/s, as shown. For a rainfall excess of 3 cm occurring uniformly over the same

3-hour duration, the peak of the resulting direct-runoff hydrograph (base flow neglected) is: **[1 mark]**



(A) $10\ \text{m}^3/\text{s}$

(B) $30\ \text{m}^3/\text{s}$

(C) $33\ \text{m}^3/\text{s}$

(D) $90\ \text{m}^3/\text{s}$

Q12. Water flows in a rectangular open channel 4 m wide at a uniform depth of 1.5 m with a mean velocity of 2 m/s. By the continuity equation $Q = AV$, the discharge carried by the channel is: **[1 mark]**

(A) $6\ \text{m}^3/\text{s}$

(B) $12\ \text{m}^3/\text{s}$

(C) $8\ \text{m}^3/\text{s}$

(D) $3\ \text{m}^3/\text{s}$

Water Supply and Water Treatment

Q13. A town's present population is $80{,}000$ and it grows geometrically at a constant rate of 2.5% per year. Using $P = P_0(1+r)^n$, the forecast population after 2 years is nearest to: **[1 mark]**

(A) $84{,}050$

(B) $82{,}000$

(C) $84{,}000$

(D) $88{,}000$

Q14. Compared with a rapid sand filter, a slow sand filter is best characterised by: **[1 mark]**

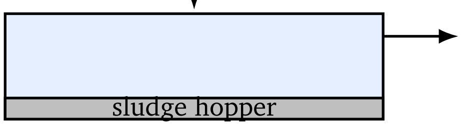
(A) a high filtration rate of about 100–150 m^3/m^2/day

(B) cleaning by daily backwashing with compressed air and water

(C) a low filtration rate of about 2.4–5 m^3/m^2/day, cleaned by scraping off the top schmutzdecke layer

(D) the compulsory use of prior coagulation and flocculation

Q15. The circular sedimentation tank shown has a diameter of 20 m and treats a flow of $Q = 3140$ m^3/day. Taking the plan area as $A = \frac{\pi D^2}{4} \approx 314$ m^2, the surface overflow rate $SOR = Q/A$ is: **[1 mark]**



diameter $D = 20$ m

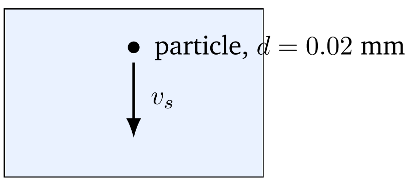
(A) 100 m/day

(B) 1 m/day

(C) 0.1 m/day

(D) 10 m/day

Q16. A discrete spherical particle of diameter $d = 0.02$ mm $= 2 \times 10^{-5}$ m and submerged density $(\rho_s - \rho) = 1600$ kg/m^3 settles in still water, as sketched. By Stokes' law $v_s = \frac{g(\rho_s - \rho)d^2}{18\mu}$ (with $\mu = 1.0 \times 10^{-3}$ Pa·s), the settling velocity is nearest to: **[1 mark]**



still water

(A) 3.5×10^{-2} m/s

(B) 3.5×10^{-3} m/s

(C) 7.0×10^{-4} m/s

(D) 3.5×10^{-4} m/s

Q17. A sedimentation tank has a volume of $V = 900$ m^3 and treats a continuous flow of $Q = 300$ m^3/hr. The theoretical hydraulic detention time $t_d = V/Q$ is: **[1 mark]**

(A) 0.33 hr

(B) 3 hr

(C) 1.5 hr

(D) 6 hr

Q18. In the disinfection of water a chlorine dose of 3.5 mg/L is applied and a free chlorine residual of 0.8 mg/L is measured after the contact period. The chlorine demand (dose minus residual) of the water is: **[1 mark]**

(A) 4.3 mg/L

(B) 0.8 mg/L

(C) 2.7 mg/L

(D) 3.5 mg/L

Wastewater Treatment and Disposal

Q19. A primary clarifier reduces the BOD of wastewater from 250 mg/L at inlet to 175 mg/L at outlet. The BOD-removal efficiency of the clarifier is: **[1 mark]**

(A) 30%

(B) 70%

(C) 25%

(D) 43%

Q20. An open sludge-drying bed dewaters digested sludge mainly by: **[1 mark]**

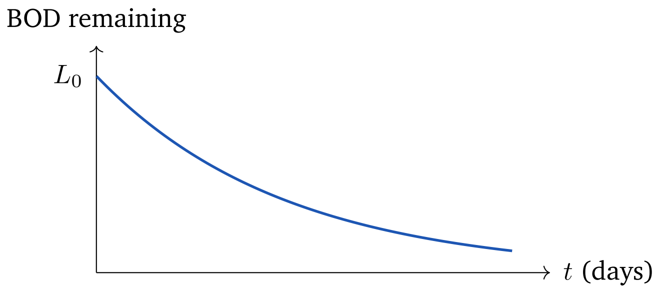
(A) evaporation of water to the atmosphere together with drainage through the underlying sand

(B) chemical precipitation of the water as a solid

(C) biological oxidation that consumes the water

(D) reverse osmosis across a membrane

Q21. Wastewater has an ultimate (first-stage) BOD of $L_0 = 250$ mg/L and a deoxygenation rate constant $k = 0.20$ day^{-1} (base e). Following the first-order decay curve shown, the BOD *remaining* (still to be exerted) after 5 days, $L_t = L_0\, e^{-kt}$, is nearest to: **[2 marks]**



first-order decay, $k = 0.20$/day

(A) 158 mg/L

(B) 46 mg/L

(C) 205 mg/L

(D) 92 mg/L

Q22. An activated-sludge aeration tank of volume $V = 1000$ m^3 operates with a mixed-liquor suspended-solids concentration of $X = 2500$ mg/L. It receives $Q = 2000$ m^3/day of wastewater at an applied BOD of $S_0 = 250$ mg/L. The food-to-microorganism ratio $F/M = \dfrac{Q\,S_0}{V\,X}$ is: **[2 marks]**

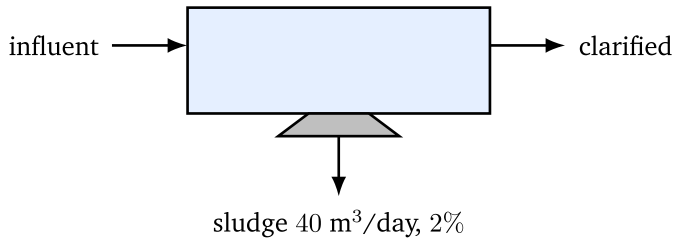
(A) 0.2 per day

(B) 0.5 per day

(C) 0.02 per day

(D) 2.0 per day

Q23. A secondary clarifier, shown below, wastes 40 m^3/day of sludge at a solids concentration of 2% by mass. Taking the sludge density as $\approx$ 1000 kg/m^3, the dry-solids mass contained in this wasted sludge is: **[2 marks]**



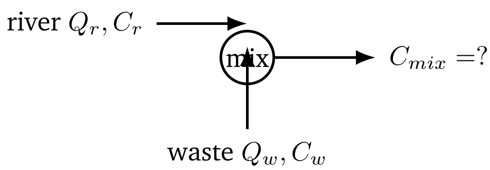
(A) 80 kg/day

(B) 2000 kg/day

(C) 800 kg/day

(D) 400 kg/day

Q24. Treated effluent is discharged into a river, as sketched. The waste stream carries $Q_w = 1.0$ m^3/s at a BOD of 150 mg/L and the receiving river carries $Q_r = 9.0$ m^3/s at a BOD of 5 mg/L. Assuming complete mixing, the BOD just downstream of the outfall $C_{mix} = \dfrac{Q_w C_w + Q_r C_r}{Q_w + Q_r}$ is nearest to: **[2 marks]**



(A) 155 mg/L

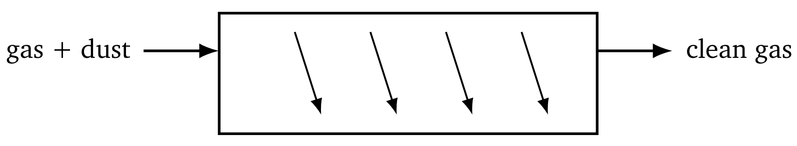
(B) 77.5 mg/L

(C) 40 mg/L

(D) 19.5 mg/L

Air Pollution and Control

Q25. In the gravity settling chamber shown, a spherical dust particle of diameter $d = 30$ μm $= 3 \times 10^{-5}$ m and density $\rho_p = 2500$ kg/m^3 settles in air of viscosity $\mu = 1.8 \times 10^{-5}$ Pa·s. Neglecting the air density, the terminal settling velocity $v_t = \dfrac{g\,\rho_p\,d^2}{18\mu}$ is nearest to: **[2 marks]**



(A) 0.68 m/s

(B) 0.0068 m/s

(C) 0.068 m/s

(D) 0.34 m/s

Q26. An electrostatic precipitator receives a gas carrying a particulate loading of 12 g/m^3 and discharges it at 0.6 g/m^3. The overall collection (removal) efficiency of the precipitator is: **[2 marks]**

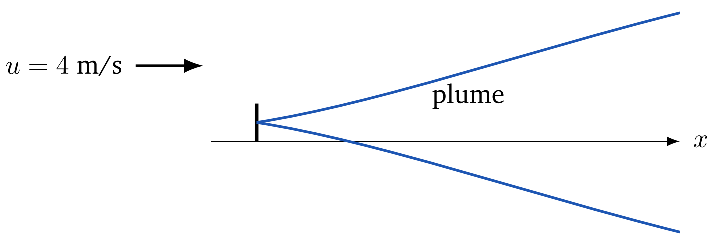
(A) 5%

(B) 95%

(C) 90%

(D) 50%

Q27. A continuous ground-level point source emits a pollutant at $Q = 120$ g/s into a wind of speed $u = 4$ m/s. For the Gaussian plume shown, the ground-level centre-line concentration is $C = \dfrac{Q}{\pi\,\sigma_y\,\sigma_z\,u}$; at the downwind location $\sigma_y = 40$ m and $\sigma_z = 20$ m, the concentration is nearest to: **[2 marks]**



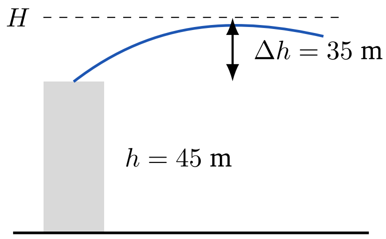
(A) 11.9 mg/m^3

(B) 5.97 mg/m^3

(C) 23.9 mg/m^3

(D) 1.19 mg/m^3

Q28. For the chimney shown, the physical stack height is $h = 45$ m and the buoyant plume rises a further $\Delta h = 35$ m above the stack top before levelling off. The effective stack height $H = h + \Delta h$ used in dispersion calculations is: **[2 marks]**



(A) 80 m

(B) 45 m

(C) 35 m

(D) 10 m

Q29. At a site the environmental (ambient) lapse rate is $5°$C/km while the dry adiabatic lapse rate is $9.8°$C/km. Because the environmental lapse rate is smaller than the adiabatic value, the atmosphere is: **[2 marks]**

(A) unstable (super-adiabatic), promoting strong vertical mixing

(B) exactly neutral

(C) stable (sub-adiabatic), suppressing vertical mixing and dispersion

(D) at the dry adiabatic limit

Q30. Ambient nitrogen dioxide is measured as 0.05 ppm by volume. At $25°$C (1 atm) the molar volume of a gas is 24.45 litres and the molecular mass of NO_2 is 46. Using $\mu g/m^3 = \text{ppm} \times \dfrac{M}{24.45} \times 1000$, the mass concentration is nearest to: **[2 marks]**

(A) $46\ \mu g/m^3$

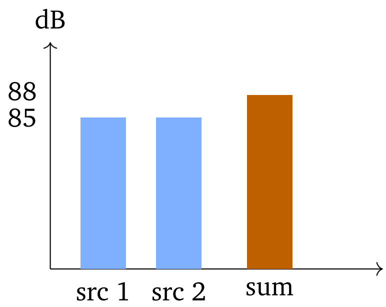
(B) $23\ \mu g/m^3$

(C) $188\ \mu g/m^3$

(D) $94\ \mu g/m^3$

Noise Pollution and Environmental Monitoring

Q31. Two identical machines each produce a sound-pressure level of 85 dB at a receiver. When both operate together, the combined level $L = 10\log_{10}\left(10^{L_1/10} + 10^{L_2/10}\right)$ is (as suggested by the energy addition shown): **[2 marks]**



(A) 85 dB

(B) 170 dB

(C) 88 dB

(D) 91 dB

Q32. At a roadside receiver, moving traffic contributes 75 dB and an air-conditioner unit contributes 69 dB. The combined sound level, using $L = 10\log_{10}\left(10^{7.5} + 10^{6.9}\right)$, is nearest to: **[2 marks]**

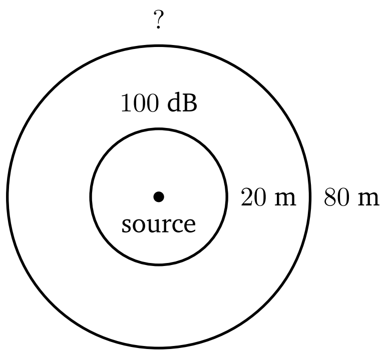
(A) 76 dB

(B) 144 dB

(C) 75 dB

(D) 81 dB

Q33. A point noise source such as an aircraft engine produces 100 dB at a distance of 20 m. In a free field the level falls by 6 dB for every doubling of distance, as the contours below suggest. The sound level at 80 m from the source is: **[2 marks]**



(A) 94 dB

(B) 82 dB

(C) 88 dB

(D) 76 dB

Q34. In traffic-noise assessment, the noise level that is exceeded for 10% of the measurement period, often used as a measure of the intrusive near-peak noise, is denoted: **[2 marks]**

(A) L_{eq}

(B) L_{90}

(C) L_{min}

(D) L_{10}

Solid and Hazardous Waste Management

Q35. A city has a population of $500{,}000$ and a per-capita municipal solid-waste (MSW) generation rate of 0.4 kg/person/day. The total MSW generated per day, expressed in tonnes, is: **[2 marks]**

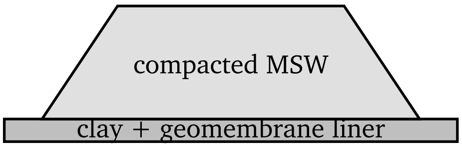
(A) 400 tonnes/day

(B) 200 tonnes/day

(C) 100 tonnes/day

(D) 50 tonnes/day

Q36. A sanitary landfill, shown in cross-section, receives 150 tonnes/day of MSW that is compacted to an in-place density of 600 kg/m^3. The landfill airspace (volume) needed for one year (365 days) of this waste is nearest to: **[2 marks]**



in-place density = 600 kg/m^3

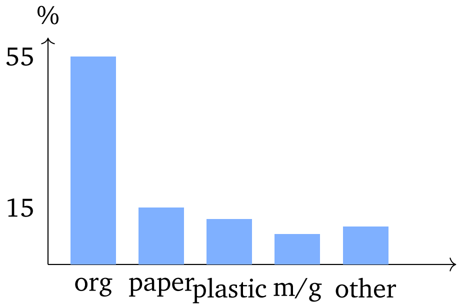
(A) 45,625 m^3

(B) 152,000 m^3

(C) 18,250 m^3

(D) 91,250 m^3

Q37. The bar chart shows the composition of a city's MSW: organic 55%, paper 15%, plastic 12%, metal/glass 8% and other 10%. If the total MSW is 200 tonnes/day, the mass of the paper fraction is: **[2 marks]**



(A) 110 tonnes/day

(B) 30 tonnes/day

(C) 24 tonnes/day

(D) 16 tonnes/day

Q38. High-level radioactive waste is most commonly immobilised for long-term storage and disposal by: **[2 marks]**

(A) open dumping in an ordinary sanitary landfill

(B) vitrification (incorporation into a stable borosilicate-glass matrix) followed by deep geological disposal

(C) dilution and discharge into the open sea

(D) aerobic composting with organic waste

Q39. A radioactive isotope in a stored waste has a half-life of 30 years. After 90 years of storage, the fraction of the original activity remaining is: [2 marks]

(A) $\frac{1}{8}$

(B) $\frac{1}{3}$

(C) $\frac{1}{2}$

(D) $\frac{1}{6}$

Q40. The "cradle-to-grave" tracking document that follows a consignment of hazardous waste from the generator through the transporter to the final treatment or disposal facility is called the: [2 marks]

(A) material safety data sheet

(B) manifest system

(C) environmental audit report

(D) mass-balance statement

Environmental Management, Sustainability and Climate

Q41. In India, the national green-building rating system developed by TERI together with the Ministry of New and Renewable Energy is: [2 marks]

(A) GRIHA (Green Rating for Integrated Habitat Assessment)

(B) the Biochemical Oxygen Demand index

(C) the Kyoto Protocol

(D) the National Air Quality Index

Q42. LEED, one of the most widely used green-building certification systems, stands for: [2 marks]

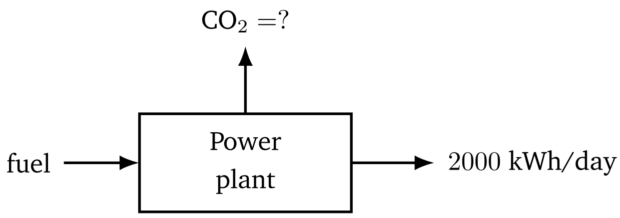
(A) Leadership in Energy and Environmental Design

(B) Low Emission Environmental Development

(C) Long-term Ecological and Economic Design

(D) Legal Environmental Enforcement Directive

Q43. For the process shown, a thermal power plant emits 0.9 kg of CO_2 for every kilowatt-hour of electricity and generates 2000 kWh each day. The daily CO_2 emission, obtained from the mass balance, is: **[2 marks]**



(A) 900 kg/day

(B) 1.8 tonnes/day

(C) 0.9 tonne/day

(D) 3.6 tonnes/day

Q44. The systematic "cradle-to-grave" evaluation of the environmental impacts of a product across raw-material extraction, manufacture, use and final disposal is called: **[2 marks]**

(A) Environmental Impact Assessment

(B) Life Cycle Assessment

(C) Environmental Audit

(D) Detailed Project Report

Q45. The international climate agreement adopted in 2015 under the UNFCCC, in which countries pledged through nationally determined contributions to hold global warming to well below $2°$C, is the: **[2 marks]**

(A) Paris Agreement

(B) Montreal Protocol

(C) Basel Convention

(D) Ramsar Convention

Q46. In a LEED or GRIHA green-building assessment, one of the most heavily weighted credit categories addresses: **[2 marks]**

(A) increasing the building's total floor area

(B) energy efficiency and the reduction of building energy demand

(C) maximising the building's water consumption

(D) using only imported construction materials

Detailed Solutions

Q1.

Solution

Concept – free-chlorine species and disinfection: When chlorine gas dissolves in water it hydrolyses to hypochlorous acid, which then dissociates into the hypochlorite ion. Together HOCl and OCl^- make up the free available chlorine.

Step 1 – write the two reactions: $Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^-$

$HOCl \rightleftharpoons H^+ + OCl^-$

Step 2 – compare the disinfecting power of the two forms: The neutral, uncharged HOCl molecule penetrates the negatively charged bacterial cell wall far more readily than the charged OCl^- ion.

Step 3 – conclude: Hypochlorous acid HOCl is therefore about 80–100 times more effective as a disinfectant than the hypochlorite ion, which is why low-pH water disinfects faster.

Why the other options are wrong:

- A, Cl^-: chloride is the fully reduced, spent form with no disinfecting action.
- B, ClO_3^-: chlorate is an oxidation by-product, not the working disinfectant.
- D, OCl^-: active but much weaker than HOCl.

Final Answer: hypochlorous acid HOCl $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept – expressing hardness as $CaCO_3$: The hardness caused by an ion equals its concentration multiplied by the ratio of the equivalent weight of $CaCO_3$ (50) to the equivalent weight of that ion.

Step 1 – equivalent weight of magnesium: Magnesium has valency 2, so its equivalent weight is $\frac{24}{2} = 12$

Step 2 – form the conversion factor: factor $= \frac{50}{12} = 4.1667$

Step 3 – multiply the magnesium concentration by the factor: Hardness $= 24 \times 4.1667$

Step 4 – evaluate: Hardness $= 100$ mg/L as $CaCO_3$

Why the other options are wrong: Options A, B and C use the raw concentration or the wrong equivalent-weight ratio and so understate the hardness.

Final Answer: 100 mg/L as $CaCO_3 \Rightarrow \boxed{D}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept – formation of disinfection by-products: Trihalomethanes (THMs) such as chloroform are chlorination by-products formed when the chlorine dose reacts with dissolved organic precursors in the raw water.

Step 1 – identify the precursor: Natural organic matter, mainly humic and fulvic acids leached from soil and decaying vegetation, supplies the carbon skeleton for THMs.

Step 2 – describe the reaction: Free chlorine substitutes onto these organic molecules, producing $CHCl_3$ and related brominated and chlorinated THMs.

Step 3 – control implication: Removing the organic precursors before chlorination (by coagulation or activated carbon) is the standard way to limit THM formation.

Why the other options are wrong:

- A, dissolved oxygen: does not form THMs.
- C, ammonia: produces chloramines, not THMs.
- D, Ca and Mg: cause hardness, not THMs.

Final Answer: natural organic matter $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q3

Q4.

Solution

Concept – definition of pH: pH is the negative base-10 logarithm of the hydrogen-ion concentration, $pH = -\log_{10}[H^+]$.

Step 1 – write the given concentration: $[H^+] = 4 \times 10^{-4}$ mol/L

Step 2 – substitute into the definition: $pH = -\log_{10}(4 \times 10^{-4})$

Step 3 – split the logarithm: $\log_{10}(4 \times 10^{-4}) = \log_{10} 4 + \log_{10} 10^{-4}$

Step 4 – evaluate each term: $\log_{10} 4 = 0.602$ and $\log_{10} 10^{-4} = -4$

Step 5 – add and negate: $\text{pH} = -(0.602 - 4) = -(-3.398)$

$\text{pH} = 3.4$

Step 6 – interpret: A pH of 3.4 is well below 7, so the water is strongly acidic, consistent with the high $[\text{H}^+]$.

Final Answer: $\text{pH} = 3.4 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept – combined (chloramine) residual: When water contains ammonia, applied chlorine first combines with it rather than remaining as free chlorine.

Step 1 – write the reaction sequence: $NH_3 + HOCl \rightarrow NH_2Cl + H_2O$ (monochloramine)

$NH_2Cl + HOCl \rightarrow NHCl_2 + H_2O$ (dichloramine)

Step 2 – name the product class: These chlorine-nitrogen compounds are collectively called chloramines, and they constitute the combined chlorine residual.

Step 3 – note the practical role: Chloramines are weaker but longer-lasting disinfectants, useful for maintaining a residual in the distribution network.

Why the other options are wrong:

- A and C: Cl_2 and HOCl are free chlorine, not the combined residual.
- B, chlorate: is an oxidation by-product, not the ammonia reaction product.

Final Answer: chloramines $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q5

Q6.

Solution

Concept – causative agent of cholera: Cholera is a classic waterborne disease spread through drinking water contaminated with faecal matter.

Step 1 – recall the pathogen: The disease is caused by the bacterium *Vibrio cholerae*, which produces a toxin causing severe watery diarrhoea.

Step 2 – link to water treatment: Proper disinfection (e.g. chlorination) readily inactivates *Vibrio cholerae*, which is why it is a target organism in water supply.

Why the other options are wrong:

- A, protozoan: causes diseases such as amoebiasis and giardiasis, not cholera.
- B, virus: causes hepatitis A/E and polio, not cholera.
- D, helminth: causes worm infestations, not cholera.

Final Answer: the bacterium *Vibrio cholerae* $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q6

Q7.

Solution

Concept – reservoir storage equation: Over a period, the change in stored water equals inflow minus the sum of outflow and losses, $\Delta S = I - O - E$.

Step 1 – list the data: $I = 50$ Mm^3, $O = 30$ Mm^3, $E = 5$ Mm^3.

Step 2 – substitute into the balance: $\Delta S = 50 - 30 - 5$

Step 3 – subtract step by step: $50 - 30 = 20$

$20 - 5 = 15$

Step 4 – state the result: $\Delta S = 15$ Mm^3 (a net gain in storage)

Final Answer: $\Delta S = 15$ Mm^3 $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q7

Q8.

Solution

Concept – runoff coefficient: The runoff coefficient is the fraction of rainfall that appears as direct runoff, $C = \dfrac{\text{runoff depth}}{\text{rainfall depth}}$.

Step 1 – list the data: Rainfall depth $= 30$ cm, runoff depth $= 12$ cm.

Step 2 – form the ratio: $C = \dfrac{12}{30}$

Step 3 – simplify: $C = \dfrac{12}{30} = 0.40$

Step 4 – sanity check: A dimensionless C between 0 and 1 is expected; 0.40 is reasonable for a mixed catchment.

Final Answer: $C = 0.40 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

Q9.

Solution

Concept – transmissivity of an aquifer: Transmissivity is the rate at which water moves through the full saturated thickness under a unit gradient, $T = K\,b$.

Step 1 – list the data: $K = 15$ m/day, $b = 20$ m.

Step 2 – substitute: $T = 15 \times 20$

Step 3 – evaluate: $T = 300\ \text{m}^2/\text{day}$

Step 4 – note the units: K (m/day) times b (m) gives m^2/day, the correct unit for transmissivity.

Final Answer: $T = 300\ \text{m}^2/\text{day} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q9

Q10.

Solution

Concept – seepage (pore) velocity: The Darcy velocity is a flux over the whole cross-section; water actually travels only through the pores, so the seepage velocity is larger, $v_s = \dfrac{v}{n}$.

Step 1 – list the data: Darcy velocity $v = 0.6$ m/day, effective porosity $n = 0.3$.

Step 2 – substitute: $v_s = \dfrac{0.6}{0.3}$

Step 3 – evaluate: $v_s = 2.0$ m/day

Step 4 – interpret: Because only 30% of the area is open pore space, the water threads through faster than the bulk Darcy value.

Final Answer: $v_s = 2.0$ m/day $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q10

Q11.

Solution

Concept – linearity (proportionality) of the unit hydrograph: A unit hydrograph is defined for 1 cm of rainfall excess. For P cm of excess over the same duration, every ordinate scales by P.

Step 1 – list the data: Unit-hydrograph peak $= 30\ \text{m}^3/\text{s}$, rainfall excess $P = 3$ cm.

Step 2 – apply the scaling factor: $Q_{peak} = P \times (\text{unit peak})$

Step 3 – substitute: $Q_{peak} = 3 \times 30$

Step 4 – evaluate: $Q_{peak} = 90\ \text{m}^3/\text{s}$

Final Answer: $Q_{peak} = 90\ \text{m}^3/\text{s} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q11

Q12.

Solution

Concept – continuity equation: The discharge equals the flow area times the mean velocity, $Q = AV$.

Step 1 – compute the flow area: For a rectangular section, $A = \text{width} \times \text{depth} = 4 \times 1.5$

$A = 6\ \text{m}^2$

Step 2 – write the continuity equation: $Q = AV$

Step 3 – substitute: $Q = 6 \times 2$

Step 4 – evaluate: $Q = 12\ \text{m}^3/\text{s}$

Final Answer: $Q = 12\ \text{m}^3/\text{s} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q12

Q13.

Solution

Concept – geometric-increase (compound) population forecast: Population grows by a constant percentage each year, so $P = P_0(1+r)^n$.

Step 1 – list the data: $P_0 = 80{,}000$, $r = 0.025$, $n = 2$ years.

Step 2 – form the growth factor: $(1+r)^n = (1.025)^2$

Step 3 – expand the square: $(1.025)^2 = 1.050625$

Step 4 – multiply by the base population: $P = 80{,}000 \times 1.050625$

Step 5 – evaluate: $P = 84{,}050$

Final Answer: $P \approx 84{,}050 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept – slow sand versus rapid sand filters: The two filter types differ sharply in loading rate and cleaning method.

Step 1 – recall the slow sand filter rate: A slow sand filter operates at a low rate of roughly $2.4–5$ m^3/m^2/day (about $0.1–0.2$ m/hr).

Step 2 – recall how it is cleaned: It is cleaned by scraping off the top biological layer, the schmutzdecke, rather than by backwashing.

Step 3 – contrast with the rapid filter: A rapid sand filter runs $20–40$ times faster and is cleaned by backwashing, usually after coagulation-flocculation of the raw water.

Why the other options are wrong:

- A and B: describe the rapid sand filter's high rate and backwashing.
- D: prior coagulation is a rapid-filter requirement, not a slow-filter one.

Final Answer: low rate, cleaned by scraping the schmutzdecke $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q14

Q15.

Solution

Concept – surface overflow rate: The surface overflow rate is the flow divided by the plan area of the tank, $SOR = Q/A$.

Step 1 – list the data: $Q = 3140$ m^3/day, $A = 314$ m^2.

Step 2 – substitute: $SOR = \dfrac{3140}{314}$

Step 3 – evaluate: $SOR = 10$ m^3/m^2/day $= 10$ m/day

Step 4 – interpret the unit: m^3/m^2/day reduces to m/day, an equivalent settling (overflow) velocity; particles with a settling velocity above 10 m/day are removed.

Final Answer: $SOR = 10$ m/day $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q15

Q16.

Solution

Concept – Stokes' law settling velocity: For a small discrete particle in the laminar regime, $v_s = \dfrac{g(\rho_s - \rho)d^2}{18\mu}$.

Step 1 – list the data: $g = 9.81$ m/s^2, $(\rho_s - \rho) = 1600$ kg/m^3, $d = 2 \times 10^{-5}$ m, $\mu = 1.0 \times 10^{-3}$ Pa·s.

Step 2 – square the diameter: $d^2 = (2 \times 10^{-5})^2 = 4 \times 10^{-10}$ m^2

Step 3 – form the numerator: $g(\rho_s - \rho)d^2 = 9.81 \times 1600 \times 4 \times 10^{-10}$

$= 9.81 \times 6.4 \times 10^{-7} = 6.278 \times 10^{-6}$

Step 4 – form the denominator: $18\mu = 18 \times 1.0 \times 10^{-3} = 1.8 \times 10^{-2}$

Step 5 – divide: $v_s = \dfrac{6.278 \times 10^{-6}}{1.8 \times 10^{-2}}$

$v_s = 3.49 \times 10^{-4}$ m/s

Final Answer: $v_s \approx 3.5 \times 10^{-4}$ m/s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept – hydraulic detention time: The detention (retention) time is the tank volume divided by the throughflow, $t_d = V/Q$.

Step 1 – list the data: $V = 900$ m^3, $Q = 300$ m^3/hr.

Step 2 – substitute: $t_d = \dfrac{900}{300}$

Step 3 – evaluate: $t_d = 3$ hr

Step 4 – check units: m$^3 \div$ (m^3/hr) gives hours, as required.

Final Answer: $t_d = 3$ hr $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q17

Q18.

Solution

Concept – chlorine demand: Chlorine demand is the amount of chlorine consumed by reacting matter, equal to the dose applied minus the residual left, demand $=$ dose $-$ residual.

Step 1 – list the data: Dose $= 3.5$ mg/L, free residual $= 0.8$ mg/L.

Step 2 – substitute: demand $= 3.5 - 0.8$

Step 3 – evaluate: demand $= 2.7$ mg/L

Step 4 – interpret: This 2.7 mg/L was consumed oxidising organics, ammonia and other reducing agents before a free residual could persist.

Final Answer: 2.7 mg/L $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q18

Q19.

Solution

Concept – BOD-removal efficiency: Efficiency is the fraction of BOD removed, $\eta = \dfrac{\text{BOD}_{in} - \text{BOD}_{out}}{\text{BOD}_{in}} \times 100\%$.

Step 1 – list the data: $\text{BOD}_{in} = 250$ mg/L, $\text{BOD}_{out} = 175$ mg/L.

Step 2 – find the amount removed: $250 - 175 = 75$ mg/L

Step 3 – divide by the inlet value: $\eta = \dfrac{75}{250}$

Step 4 – convert to a percentage: $\eta = 0.30 = 30\%$

Step 5 – sanity check: A primary clarifier typically removes 25–35% of BOD, so 30% is realistic.

Final Answer: $\eta = 30\% \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q19

Q20.

Solution

Concept – sludge-drying beds: A drying bed is an open, sand-and-gravel-lined basin onto which digested sludge is spread in a thin layer to dewater naturally.

Step 1 – identify the two removal paths: Water leaves the sludge partly by evaporation from the exposed surface and partly by drainage (percolation) through the underlying sand and underdrains.

Step 2 – describe the outcome: As moisture is lost, the sludge cake shrinks and cracks, allowing further evaporation until it is spadable and can be lifted for disposal.

Why the other options are wrong:

- B: no chemical precipitation of water occurs; water is physically removed.
- C: microbes do not "consume" the water.

- D: reverse osmosis is a pressurised membrane process, not the mechanism of an open bed.

Final Answer: evaporation plus drainage through sand $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q20

Q21.

Solution

Concept – first-order BOD decay (remaining BOD): The BOD still remaining after time t follows $L_t = L_0\, e^{-kt}$, where L_0 is the ultimate BOD.

Step 1 – list the data: $L_0 = 250$ mg/L, $k = 0.20$ day^{-1}, $t = 5$ days.

Step 2 – form the exponent: $kt = 0.20 \times 5 = 1.0$

Step 3 – evaluate the exponential: $e^{-1.0} = 0.3679$

Step 4 – multiply by L_0: $L_t = 250 \times 0.3679$

Step 5 – evaluate: $L_t = 91.97 \approx 92$ mg/L

Why the other options are wrong:

- C, 205 mg/L: is the wrong direction (nearly the whole ultimate BOD).
- A and B: use incorrect exponents.

Final Answer: $L_t \approx 92$ mg/L $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q21

Q22.

Solution

Concept – food-to-microorganism ratio: The F/M ratio compares the organic load applied with the mass of microorganisms in the aeration tank, $F/M = \dfrac{Q\,S_0}{V\,X}$.

Step 1 – list the data: $Q = 2000$ m^3/day, $S_0 = 250$ mg/L, $V = 1000$ m^3, $X = 2500$ mg/L.

Step 2 – form the numerator (food supplied): $Q\,S_0 = 2000 \times 250 = 500{,}000$

Step 3 – form the denominator (microbial mass): $V\,X = 1000 \times 2500 = 2{,}500{,}000$

Step 4 – divide: $F/M = \dfrac{500{,}000}{2{,}500{,}000}$

Step 5 – evaluate: $F/M = 0.20$ per day

Step 6 – sanity check: Conventional activated sludge runs at $F/M \approx 0.2$–0.5 per day, so the value is typical.

Final Answer: $F/M = 0.2$ per day $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q22

Q23.

Solution

Concept – dry-solids mass in a sludge stream: The dry-solids mass is the sludge mass flow times the fractional solids content.

Step 1 – convert the sludge volume to mass: With density ≈ 1000 kg/m^3, 40 m^3/day $= 40 \times 1000 = 40{,}000$ kg/day.

Step 2 – write the solids fraction: 2% solids $= 0.02$ (as a decimal fraction).

Step 3 – multiply: dry solids $= 40{,}000 \times 0.02$

Step 4 – evaluate: dry solids $= 800$ kg/day

Step 5 – interpret: The remaining $39{,}200$ kg/day is water, showing why thickening and dewatering greatly reduce the volume to be disposed.

Final Answer: 800 kg/day of dry solids $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept – complete-mixing mass balance at an outfall: When two streams merge and mix fully, the mixed concentration is the flow-weighted average, $C_{mix} = \dfrac{Q_wC_w + Q_rC_r}{Q_w + Q_r}$.

Step 1 – list the data: $Q_w = 1.0$ m^3/s, $C_w = 150$ mg/L, $Q_r = 9.0$ m^3/s, $C_r = 5$ mg/L.

Step 2 – compute each mass-flux term: $Q_wC_w = 1.0 \times 150 = 150$

$Q_rC_r = 9.0 \times 5 = 45$

Step 3 – add the fluxes: $150 + 45 = 195$

Step 4 – add the flows: $Q_w + Q_r = 1.0 + 9.0 = 10$ m^3/s

Step 5 – divide: $C_{mix} = \dfrac{195}{10} = 19.5$ mg/L

Final Answer: $C_{mix} \approx 19.5$ mg/L $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept – terminal settling velocity in a settling chamber: For fine dust in the laminar regime, $v_t = \dfrac{g\,\rho_p\,d^2}{18\mu}$ (air density neglected).

Step 1 – list the data: $g = 9.81$ m/s^2, $\rho_p = 2500$ kg/m^3, $d = 3 \times 10^{-5}$ m, $\mu = 1.8 \times 10^{-5}$ Pa·s.

Step 2 – square the diameter: $d^2 = (3 \times 10^{-5})^2 = 9 \times 10^{-10}$ m^2

Step 3 – form the numerator: $g\,\rho_p\,d^2 = 9.81 \times 2500 \times 9 \times 10^{-10}$

$= 24{,}525 \times 9 \times 10^{-10} = 2.207 \times 10^{-5}$

Step 4 – form the denominator: $18\mu = 18 \times 1.8 \times 10^{-5} = 3.24 \times 10^{-4}$

Step 5 – divide: $v_t = \dfrac{2.207 \times 10^{-5}}{3.24 \times 10^{-4}}$

$v_t = 0.0681$ m/s

Final Answer: $v_t \approx 0.068$ m/s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q25

Q26.

Solution

Concept – collection (removal) efficiency: Efficiency is the fraction of the incoming particulate that is captured, $\eta = \dfrac{C_{in} - C_{out}}{C_{in}} \times 100\%$.

Step 1 – list the data: $C_{in} = 12$ g/m^3, $C_{out} = 0.6$ g/m^3.

Step 2 – find the amount removed: $12 - 0.6 = 11.4$ g/m^3

Step 3 – divide by the inlet loading: $\eta = \dfrac{11.4}{12}$

Step 4 – convert to a percentage: $\eta = 0.95 = 95\%$

Step 5 – sanity check: Electrostatic precipitators routinely achieve 95–99% removal, so the answer is consistent.

Final Answer: $\eta = 95\% \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept – Gaussian plume, ground-level source on the centre line: For a continuous ground-level point source, the ground-level centre-line concentration is $C = \dfrac{Q}{\pi\,\sigma_y\,\sigma_z\,u}$.

Step 1 – list the data: $Q = 120$ g/s, $\sigma_y = 40$ m, $\sigma_z = 20$ m, $u = 4$ m/s.

Step 2 – form the denominator step by step: $\sigma_y\,\sigma_z = 40 \times 20 = 800$

$\sigma_y\,\sigma_z\,u = 800 \times 4 = 3200$

$\pi\,\sigma_y\,\sigma_z\,u = 3.1416 \times 3200 = 10{,}053$

Step 3 – divide: $C = \dfrac{120}{10{,}053}$

$C = 0.01194$ g/m^3

Step 4 – convert to mg/m^3: $C = 0.01194 \times 1000 = 11.94$ mg/m^3

Final Answer: $C \approx 11.9$ mg/m^3 $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q27

Q28.

Solution

Concept – effective stack height: The effective stack height is the physical height plus the plume rise, $H = h + \Delta h$; dispersion models treat the plume as if released from H.

Step 1 – list the data: $h = 45$ m, $\Delta h = 35$ m.

Step 2 – add: $H = 45 + 35$

Step 3 – evaluate: $H = 80$ m

Step 4 – interpret: The buoyant rise of 35 m lifts the effective release point to 80 m, lowering ground-level concentrations downwind.

Final Answer: $H = 80$ m $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q28

Q29.

Solution

Concept – atmospheric stability from lapse-rate comparison: Stability is judged by comparing the environmental lapse rate (ELR) with the dry adiabatic lapse rate (DALR $\approx 9.8°$C/km). If ELR $<$ DALR, the atmosphere is stable.

Step 1 – state the two rates: ELR $= 5°$C/km, DALR $= 9.8°$C/km.

Step 2 – compare: $5 < 9.8$, so ELR is less than DALR (sub-adiabatic).

Step 3 – reason about a rising parcel: A displaced parcel cools at the DALR and quickly becomes colder and denser than its surroundings, so it sinks back. Vertical motion is suppressed.

Step 4 – conclude: The atmosphere is stable, which limits mixing and traps pollutants near the ground.

Why the other options are wrong:

- A: unstable needs ELR $>$ DALR.
- B and D: neutral needs ELR $=$ DALR.

Final Answer: stable (sub-adiabatic) $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q29

Q30.

Solution

Concept – converting ppm (volume) to mass concentration: At $25°$C, $\mu g/m^3 = \text{ppm} \times \frac{M}{24.45} \times 1000$, where M is the molecular mass.

Step 1 – list the data: ppm $= 0.05$, $M = 46$ (NO_2), molar volume $= 24.45$ L.

Step 2 – form the mass-per-mole factor: $\frac{M}{24.45} = \frac{46}{24.45} = 1.8814$

Step 3 – multiply by 1000**:** $1.8814 \times 1000 = 1881.4$

Step 4 – multiply by the ppm value: $0.05 \times 1881.4 = 94.07$

Step 5 – state the result: Mass concentration $\approx 94\ \mu g/m^3$.

Final Answer: $94\ \mu g/m^3 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q30

Q31.

Solution

Concept – energy addition of equal sound levels: Sound levels add on an energy (intensity) basis, $L = 10\log_{10}\left(10^{L_1/10} + 10^{L_2/10}\right)$. Two equal levels double the energy.

Step 1 – list the data: $L_1 = L_2 = 85$ dB.

Step 2 – write the sum of energies: $10^{85/10} + 10^{85/10} = 2 \times 10^{8.5}$

Step 3 – take the logarithm of the doubling: $L = 10\log_{10}(2 \times 10^{8.5}) = 10\left(\log_{10} 2 + 8.5\right)$

Step 4 – evaluate $\log_{10} 2$: $\log_{10} 2 = 0.301$

Step 5 – combine: $L = 10(0.301 + 8.5) = 10 \times 8.801 = 88.01$

$L \approx 88$ dB

Step 6 – note the rule: Doubling the number of equal sources always adds about 3 dB, not double the decibels.

Final Answer: $L \approx 88$ dB $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q31

Q32.

Solution

Concept – combining two unequal sound levels: $L = 10\log_{10}\left(10^{L_1/10} + 10^{L_2/10}\right)$.

Step 1 – list the data: $L_1 = 75$ dB, $L_2 = 69$ dB.

Step 2 – convert each level to relative energy: $10^{7.5} = 3.162 \times 10^7$

$10^{6.9} = 7.943 \times 10^6$

Step 3 – add the energies: $3.162 \times 10^7 + 0.7943 \times 10^7 = 3.956 \times 10^7$

Step 4 – take the logarithm: $\log_{10}(3.956 \times 10^7) = 7.597$

Step 5 – multiply by 10: $L = 10 \times 7.597 = 75.97$

$L \approx 76$ dB

Step 6 – interpret: The louder 75 dB source dominates; the quieter one lifts the total by only about 1 dB.

Final Answer: $L \approx 76$ dB $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q32

Q33.

Solution

Concept – distance attenuation of a point source: In a free field the level drops by 6 dB each time the distance from a point source doubles (inverse-square law).

Step 1 – list the data: 100 dB at 20 m; find the level at 80 m.

Step 2 – count the doublings from 20 m to 80 m: $20 \to 40$ m is one doubling; $40 \to 80$ m is a second doubling; so 2 doublings.

Step 3 – compute the total drop: $2 \times 6 = 12$ dB

Step 4 – subtract from the reference level: $L = 100 - 12$

$L = 88$ dB

Final Answer: $L = 88$ dB $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q33

Q34.

Solution

Concept – statistical (percentile) noise indices: L_N is the level exceeded for $N\%$ of the measurement time. L_{10} is exceeded only 10% of the time and represents the intrusive, near-peak traffic noise.

Step 1 – interpret the definition asked for: "Exceeded for 10% of the period" is exactly L_{10}.

Step 2 – contrast the other indices: L_{90} (exceeded 90% of the time) represents the background level, and L_{eq} is the equivalent continuous level.

Why the other options are wrong:

- A, L_{eq}: an energy-average, not a percentile.
- B, L_{90}: the residual/background level.
- C, L_{min}: the lowest instantaneous level.

Final Answer: $L_{10} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q34

Q35.

Solution

Concept – total MSW generation: Total daily waste equals population times the per-capita generation rate.

Step 1 – list the data: Population $= 500{,}000$, rate $= 0.4$ kg/person/day.

Step 2 – multiply: MSW $= 500{,}000 \times 0.4$

Step 3 – evaluate in kilograms: MSW $= 200{,}000$ kg/day

Step 4 – convert to tonnes: MSW $= \dfrac{200{,}000}{1000} = 200$ tonnes/day

Final Answer: 200 tonnes/day $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q35

Q36.

Solution

Concept – landfill airspace from mass and compacted density: Volume equals mass divided by in-place density; multiply the daily volume by the number of days.

Step 1 – convert the daily mass to kilograms: 150 tonnes/day $= 150 \times 1000 = 150{,}000$ kg/day.

Step 2 – find the daily volume: $V_{day} = \dfrac{150{,}000}{600} = 250\ \text{m}^3/\text{day}$

Step 3 – multiply by 365 days: $V_{year} = 250 \times 365$

Step 4 – evaluate: $V_{year} = 91{,}250\ \text{m}^3$

Final Answer: $\approx 91{,}250\ \text{m}^3 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q36

Q37.

Solution

Concept – mass of a waste fraction from its percentage: The mass of a component equals its percentage share times the total waste mass.

Step 1 – list the data: Paper share $= 15\%$, total MSW $= 200$ tonnes/day.

Step 2 – write the percentage as a fraction: $15\% = 0.15$

Step 3 – multiply: paper $= 0.15 \times 200$

Step 4 – evaluate: paper $= 30$ tonnes/day

Step 5 – check consistency: Organic 110 + paper 30 + plastic 24 + metal/glass

16 + other $20 = 200$ tonnes/day, confirming the split.

Final Answer: 30 tonnes/day $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q37

Q38.

Solution

Concept – immobilisation of high-level radioactive waste: High-level waste (HLW) is intensely radioactive and long-lived, so it must be locked into a durable, leach-resistant solid before disposal.

Step 1 – recall the standard treatment: HLW is vitrified, that is, fused into a stable borosilicate-glass matrix that traps the radionuclides.

Step 2 – describe the disposal step: The glass logs are sealed in stainless-steel canisters and destined for deep geological repositories where they stay isolated for very long times.

Why the other options are wrong:

- A: ordinary landfills give no containment against long-lived radioactivity.
- C: sea dilution and discharge is banned and dangerous.
- D: composting is for biodegradable waste, irrelevant to radionuclides.

Final Answer: vitrification then deep geological disposal $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q38

Q39.

Solution

Concept – radioactive decay by half-lives: After each half-life the activity halves, so after n half-lives the remaining fraction is $\left(\frac{1}{2}\right)^n$.

Step 1 – find the number of half-lives: $n = \dfrac{\text{elapsed time}}{\text{half-life}} = \dfrac{90}{30} = 3$

Step 2 – apply the halving rule: fraction $= \left(\dfrac{1}{2}\right)^3$

Step 3 – evaluate: $\left(\dfrac{1}{2}\right)^3 = \dfrac{1}{8}$

Step 4 – interpret: Only 12.5% of the original activity remains after three half-lives, which is why long-lived isotopes need very long storage.

Final Answer: $\frac{1}{8}$ of the original activity $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q39

Q40.

Solution

Concept – hazardous-waste manifest: Hazardous waste must be tracked from "cradle to grave" by a controlled paper/electronic document.

Step 1 – identify the document: The manifest system accompanies each consignment, recording the generator, transporter and receiving disposal facility.

Step 2 – state its purpose: It ensures that the waste actually reaches an authorised treatment/disposal site and cannot be dumped illegally en route.

Why the other options are wrong:

- A, MSDS: gives hazard and handling data for a substance, not consignment tracking.
- C, environmental audit: reviews overall compliance, not a single shipment.
- D, mass balance: is a quantitative accounting tool, not a tracking document.

Final Answer: the manifest system $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q40

Q41.

Solution

Concept – Indian green-building rating system: India uses a dedicated national rating tool to certify environmentally sound buildings.

Step 1 – recall the developer and name: GRIHA, the Green Rating for Integrated Habitat Assessment, was developed by TERI and adopted by the Ministry of New and Renewable Energy as the national rating system.

Step 2 – note what it scores: It awards points for site planning, energy and water efficiency, materials, waste management and indoor environment, on a star scale.

Why the other options are wrong:

- B, BOD: is a water-pollution parameter, not a rating system.
- C, Kyoto Protocol: is a climate treaty.
- D, Air Quality Index: reports ambient air pollution, not building perfor-

mance.

Final Answer: GRIHA $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q41

Q42.

Solution

Concept – meaning of the LEED acronym: LEED is an internationally recognised green-building certification developed by the U.S. Green Building Council.

Step 1 – expand the acronym: LEED stands for Leadership in Energy and Environmental Design.

Step 2 – note its scope: It rates buildings across energy, water, materials, site and indoor-environment credits, awarding Certified, Silver, Gold or Platinum levels.

Why the other options are wrong: Options B, C and D are invented expansions that do not match the established name of the system.

Final Answer: Leadership in Energy and Environmental Design $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q42

Q43.

Solution

Concept – emission from an emission factor: Total emission equals the emission factor times the activity level (here energy generated).

Step 1 – list the data: Emission factor $= 0.9$ kg CO_2/kWh, generation $= 2000$ kWh/day.

Step 2 – multiply: $CO_2 = 0.9 \times 2000$

Step 3 – evaluate in kilograms: $CO_2 = 1800$ kg/day

Step 4 – convert to tonnes: $CO_2 = \frac{1800}{1000} = 1.8$ tonnes/day

Final Answer: 1.8 tonnes/day $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q43

Q44.

Solution

Concept – Life Cycle Assessment (LCA): LCA is the systematic study of a product's environmental burden over its entire life, from raw-material extraction to final disposal.

Step 1 – match the description: "Cradle-to-grave across extraction, manufacture, use and disposal" is precisely the definition of Life Cycle Assessment.

Step 2 – note its stages: LCA comprises goal and scope definition, inventory analysis, impact assessment and interpretation.

Why the other options are wrong:

- A, EIA: assesses a specific project or development, not a product's whole life cycle.
- C, environmental audit: checks compliance of an existing operation.
- D, DPR: is an engineering project report, not an impact study.

Final Answer: Life Cycle Assessment $\Rightarrow \boxed{\text{B}}$

$\boxed{\textbf{Answer: (B)}}$ **Go Back to Q44**

Q45.

Solution

Concept – the 2015 climate agreement: Under the UNFCCC, a landmark climate treaty was adopted in Paris in 2015.

Step 1 – recall the agreement: The Paris Agreement commits parties, through nationally determined contributions (NDCs), to hold the global temperature rise well below $2°$C and to pursue efforts to limit it to $1.5°$C.

Why the other options are wrong:

- B, Montreal Protocol: protects the ozone layer by phasing out CFCs.
- C, Basel Convention: controls transboundary movement of hazardous waste.
- D, Ramsar Convention: protects wetlands.

Final Answer: the Paris Agreement $\Rightarrow \boxed{\text{A}}$

$\boxed{\textbf{Answer: (A)}}$ **Go Back to Q45**

Q46.

Solution

Concept – credit weighting in green-building rating: Both LEED and GRIHA award the largest share of their credits to reducing the building's operational energy use, since energy drives most life-cycle emissions.

Step 1 – identify the dominant category: Energy efficiency and demand reduction (efficient HVAC, lighting, envelope, on-site renewables) carry the heaviest weighting.

Step 2 – justify the emphasis: Buildings consume a large share of national electricity, so cutting energy demand yields the biggest environmental payoff, which the rating scales reflect.

Why the other options are wrong:

- A: larger floor area increases, not reduces, impact and earns no credit.
- C: maximising water use is the opposite of a green goal.
- D: importing materials adds transport emissions; local sourcing is favoured instead.

Final Answer: energy efficiency and demand reduction $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q46

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	D	3	B	4	A	5	D
6	C	7	D	8	B	9	C	10	C
11	D	12	B	13	A	14	C	15	D
16	D	17	B	18	C	19	A	20	A
21	D	22	A	23	C	24	D	25	C
26	B	27	A	28	A	29	C	30	D
31	C	32	A	33	C	34	D	35	B
36	D	37	B	38	B	39	A	40	B
41	A	42	A	43	B	44	B	45	A
46	B								