# GATE Environmental Science and Engineering

## Sample Paper – 5

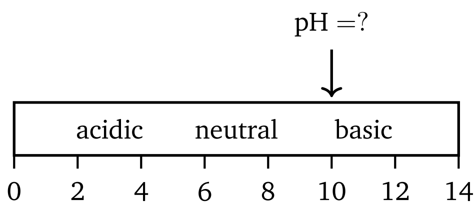
**Duration: 128 Minutes** **Maximum Marks: 72**

### 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.** At $25°$C a water sample has a hydroxyl-ion concentration $[\text{OH}^-] = 1 \times 10^{-4}$ mol/L. On the scale shown, its pH ($= 14 -$ pOH) is: **[1 mark]**



(A) 10

(B) 4

(C) 7

(D) 14

**Q2.** A water sample contains calcium ions at a concentration of 40 mg/L (atomic mass of Ca $= 40$, valency 2). Expressed as an equivalent concentration of calcium carbonate, the calcium hardness is: **[1 mark]**

(A) 40 mg/L as $CaCO_3$

(B) 200 mg/L as $CaCO_3$

(C) 100 mg/L as $CaCO_3$

(D) 50 mg/L as $CaCO_3$

**Q3.** A water sample has a total hardness of 250 mg/L as $CaCO_3$ and a total alkalinity of 180 mg/L as $CaCO_3$. The non-carbonate (permanent) hardness of the water is: **[1 mark]**

(A) 180 mg/L as $CaCO_3$

(B) 250 mg/L as $CaCO_3$

(C) 430 mg/L as $CaCO_3$

(D) 70 mg/L as $CaCO_3$

**Q4.** The alkalinity of a water is due entirely to bicarbonate present at 61 mg/L as $HCO_3^-$ (molar mass of $HCO_3^- = 61$, valency 1). Expressed as calcium carbonate, this alkalinity is: **[1 mark]**

(A) 50 mg/L as $CaCO_3$

(B) 61 mg/L as $CaCO_3$

(C) 122 mg/L as $CaCO_3$

(D) 30.5 mg/L as $CaCO_3$

**Q5.** In biological nitrification, the autotrophic bacteria *Nitrosomonas* and *Nitrobacter* derive their energy by oxidising: **[1 mark]**

(A) organic carbon to carbon dioxide

(B) sulphate to sulphide

(C) ammonium to nitrite and then nitrite to nitrate

(D) methane to carbon dioxide

**Q6.** The standard biochemical oxygen demand (BOD) test for water and wastewater is conventionally carried out by incubating the sample in the dark for a fixed period and temperature of: **[1 mark]**

(A) $3$ days at $27°$C

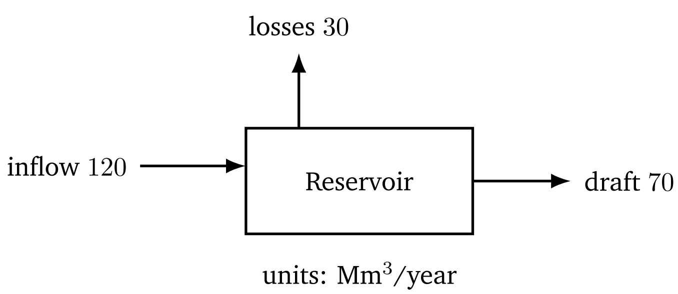
(B) $7$ days at $25°$C

(C) $1$ day at $35°$C

(D) $5$ days at $20°$C

## Water Resources and Environmental Hydraulics

**Q7.** For the reservoir mass balance shown, the annual inflow is $120$ Mm$^3$, the losses (evaporation plus seepage) are $30$ Mm$^3$ and the demand draft is $70$ Mm$^3$. The change in storage over the year, $\Delta S =$ inflow − losses − draft, is: **[1 mark]**




(A) $+50$ Mm$^3$ (increase)

(B) $+20$ Mm$^3$ (increase)

(C) $+220$ Mm$^3$ (increase)

(D) $+70$ Mm$^3$ (increase)

**Q8.** Using the rational formula $Q = \dfrac{C\,i\,A}{360}$ (with $i$ in mm/hr and $A$ in hectares giving $Q$ in m$^3$/s), a catchment has runoff coefficient $C = 0.5$, rainfall intensity $i = 72$ mm/hr and area $A = 50$ ha. The peak runoff $Q$ is: **[1 mark]**

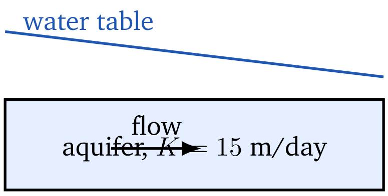
(A) $10$ m$^3$/s

(B) $5$ m$^3$/s

(C) $2.5$ m$^3$/s

(D) $1800$ m$^3$/s

**Q9.** For the unconfined aquifer shown, Darcy's law gives the specific-discharge (Darcy) velocity $v = K\,i$. With hydraulic conductivity $K = 15$ m/day and hydraulic gradient $i = 0.04$, the Darcy velocity is: **[1 mark]**




hydraulic gradient $i = 0.04$

(A) $6$ m/day

(B) $0.06$ m/day

(C) $15$ m/day

(D) $0.6$ m/day

**Q10.** A confined aquifer of thickness $b = 15$ m and hydraulic conductivity $K = 30$ m/day carries groundwater under a hydraulic gradient $i = 0.002$ across a width $W = 500$ m. The volumetric flow $Q = K\,i\,(b\,W)$ through this section is: **[1 mark]**

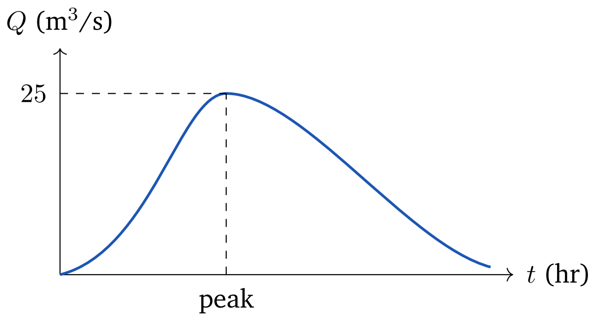
(A) $450$ m$^3$/day

(B) $45$ m$^3$/day

(C) $4500$ m$^3$/day

(D) $4.5\ \text{m}^3/\text{day}$

**Q11.** A 3-hour unit hydrograph of a catchment has a peak ordinate of $25\ \text{m}^3/\text{s}$, 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 is: **[1 mark]**




(A) $25\ \text{m}^3/\text{s}$

(B) $150\ \text{m}^3/\text{s}$

(C) $75\ \text{m}^3/\text{s}$

(D) $8.33\ \text{m}^3/\text{s}$

**Q12.** Water flows in a wide open channel. By Manning's equation $V = \dfrac{1}{n} R^{2/3} S^{1/2}$, with Manning's roughness $n = 0.013$, hydraulic radius $R = 1$ m and bed slope $S = 0.0001$, the mean velocity of flow is nearest to: **[1 mark]**

(A) $0.077$ m/s

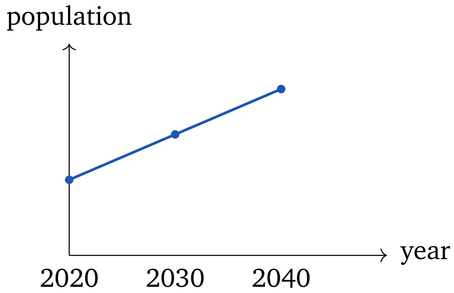
(B) $7.7$ m/s

(C) $0.77$ m/s

(D) $0.01$ m/s

## Water Supply and Water Treatment

**Q13.** A town's population in the year $2020$ is $60{,}000$ and its average decadal increase (arithmetic-increase method) is $8{,}000$ persons, as trended below. The forecast population for the year $2040$ is: **[1 mark]**




(A) 68,000

(B) 16,000

(C) 84,000

(D) 76,000

**Q14.** A city with a population of 200,000 has an average water demand of 150 litres per capita per day (lpcd). The average daily water demand of the city, expressed in million litres per day (MLD), is: **[1 mark]**

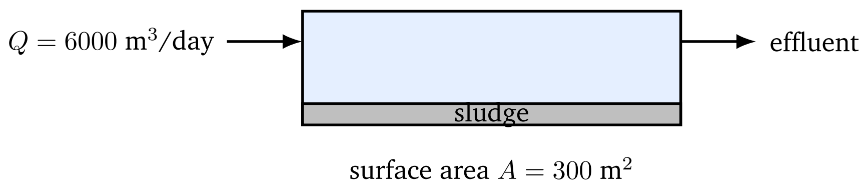
(A) 30 MLD

(B) 3 MLD

(C) 300 MLD

(D) 150 MLD

**Q15.** A rectangular sedimentation tank shown treats a flow of $Q = 6000$ $m^3$/day and has a plan (surface) area of $A = 300$ $m^2$. The surface overflow rate (surface loading) $SOR = Q/A$ is: **[1 mark]**



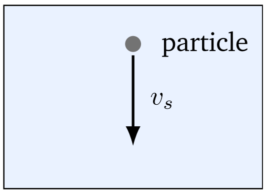

(A) 0.05 m/day

(B) 2 m/day

(C) 20 m/day

(D) 200 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. By Stokes' law $v_s = \dfrac{g(\rho_s - \rho)d^2}{18\mu}$ (with $\mu = 1.0 \times 10^{-3}$ Pa·s), the settling velocity is nearest to: **[1 mark]**




still water

(A) $3.5 \times 10^{-3}$ m/s

(B) $3.5 \times 10^{-4}$ m/s

(C) $7.0 \times 10^{-4}$ m/s

(D) $1.7 \times 10^{-4}$ m/s

**Q17.** Groundwater rich in dissolved iron is aerated (for example by a spray or cascade) before filtration. The chief purpose of this aeration step is to: **[1 mark]**

(A) oxidise soluble ferrous iron to the insoluble ferric form so that it can be settled and filtered out

(B) add fluoride to the water

(C) increase the total hardness of the water

(D) sharply lower the pH of the water

**Q18.** In the disinfection of water, a chlorine dose of $3.0$ mg/L is applied and a free chlorine residual of $0.4$ mg/L is measured after the contact period. The chlorine demand of the water is: **[1 mark]**

(A) $3.4$ mg/L

(B) $0.4$ mg/L

(C) $2.6$ mg/L

(D) $3.0$ mg/L

## Wastewater Treatment and Disposal

**Q19.** The influent to a treatment unit has a BOD of $250$ mg/L and the effluent leaving it has a BOD of $25$ mg/L. The BOD-removal efficiency of the unit is: **[1 mark]**

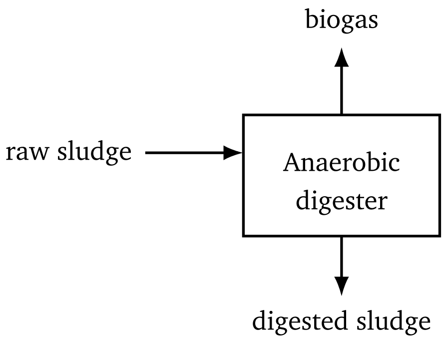
(A) $10\%$

(B) $25\%$

(C) $225\%$

(D) $90\%$

**Q20.** In the anaerobic digestion of sewage sludge whose flow scheme is shown, the two principal gases produced during the methanogenic (gas-forming) stage are: **[1 mark]**



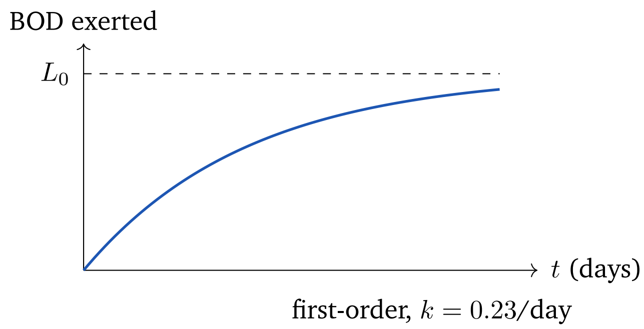

(A) oxygen and nitrogen

(B) hydrogen and oxygen

(C) ammonia and chlorine

(D) methane and carbon dioxide

**Q21.** Wastewater has an ultimate (first-stage) BOD of $L_0 = 250$ mg/L and a deoxygenation rate constant $k = 0.23$ day$^{-1}$ (base $e$). Following the first-order model of the BOD-exertion curve shown, the BOD exerted in $5$ days, $y_5 = L_0\left(1 - e^{-kt}\right)$, is nearest to: **[2 marks]**




(A) 205 mg/L

(B) 171 mg/L

(C) 250 mg/L

(D) 95 mg/L

**Q22.** An activated-sludge aeration tank of volume $V = 800$ m$^3$ operates with a mixed-liquor suspended-solids concentration of $X = 2500$ mg/L. It receives $Q = 1600$ 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]**

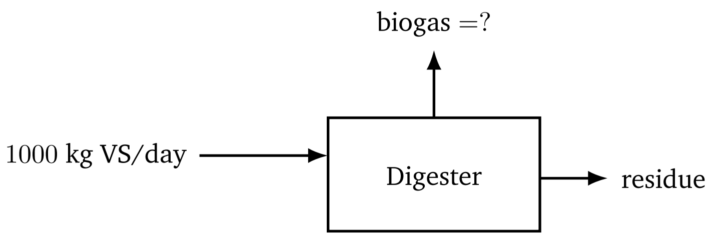
(A) 2.0 per day

(B) 0.2 per day

(C) 0.02 per day

(D) 0.4 per day

**Q23.** An anaerobic sludge digester destroys 1000 kg of volatile solids (VS) per day. If the biogas yield is 0.9 m$^3$ of gas per kilogram of volatile solids destroyed, the daily biogas production is: **[2 marks]**



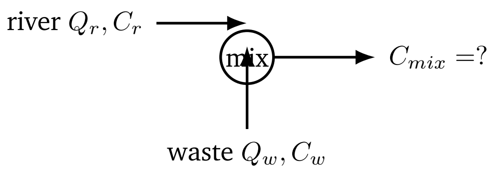

(A) 900 m$^3$/day

(B) 1111 m$^3$/day

(C) 90 m$^3$/day

(D) 9000 m$^3$/day

**Q24.** Treated wastewater is discharged into a stream, as sketched. The waste stream carries $Q_w = 1$ m$^3$/s at a BOD of 180 mg/L and the receiving river carries $Q_r = 9$ m$^3$/s at a BOD of 3 mg/L. Assuming complete mixing, the BOD just downstream of the outfall is nearest to: **[2 marks]**




(A) 183 mg/L

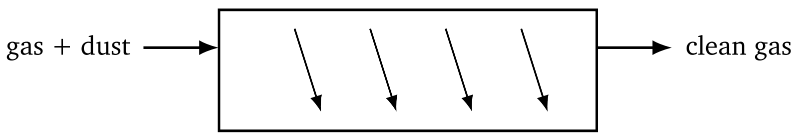
(B) 90 mg/L

(C) 20.7 mg/L

(D) 40 mg/L

## Air Pollution and Control

**Q25.** In the gravity settling chamber shown, a spherical dust particle of diameter $d = 30\ \mu$m $= 3 \times 10^{-5}$ 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]**




particle settles under gravity

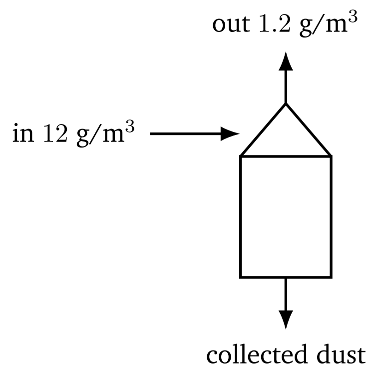
(A) 0.68 m/s

(B) 0.068 m/s

(C) 0.0068 m/s

(D) 6.8 m/s

**Q26.** A cyclone separator receives a gas carrying a particulate loading of 12 g/m$^3$ and discharges it at 1.2 g/m$^3$. The overall collection (removal) efficiency of the cyclone is: **[2 marks]**



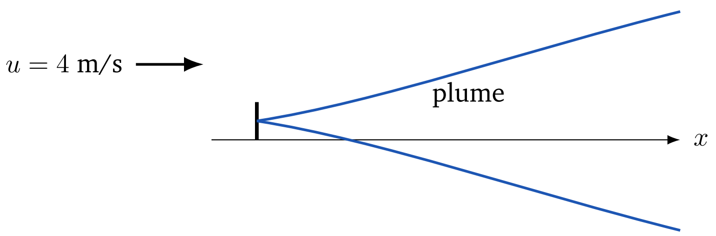

(A) 95%

(B) 10%

(C) 50%

(D) 90%

**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]**



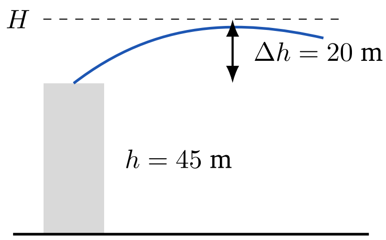

(A) 11.9 mg/m$^3$

(B) 23.9 mg/m$^3$

(C) 5.97 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 $\Delta h = 20$ m above the stack top before levelling off. The effective stack height $H = h + \Delta h$ is: **[2 marks]**




(A) 45 m

(B) 20 m

(C) 65 m

(D) 90 m

**Q29.** In atmospheric stability analysis, the actual rate at which air temperature decreases with altitude in the real atmosphere, the environmental (normal) lapse rate, is on average approximately: **[2 marks]**

(A) 9.8°C/km

(B) 6.5°C/km

(C) 0.98°C/km

(D) 1.0°C/km

**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$^3$

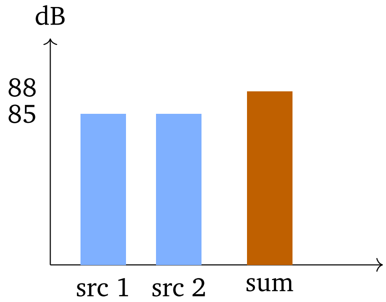
(B) 46.9 $\mu$g/m$^3$

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

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

## Noise Pollution and Environmental Monitoring

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




(A) 88 dB

(B) 170 dB

(C) 85 dB

(D) 91 dB

**Q32.** Under the OSHA noise standard, a continuous exposure of 90 dBA is permitted for 8 hours, and the permissible exposure time halves for every 5 dBA increase (a 5-dB exchange rate). The permissible daily exposure time at 95 dBA is: **[2 marks]**

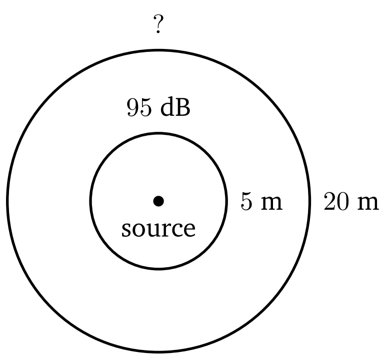
(A) 8 hours

(B) 2 hours

(C) 1 hour

(D) 4 hours

**Q33.** A point noise source produces 95 dB at a distance of 5 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 20 m from the source is: **[2 marks]**




(A) 89 dB

(B) 83 dB

(C) 95 dB

(D) 77 dB

**Q34.** In environmental noise monitoring, the A-weighted sound level that is exceeded for $10\%$ of the measurement period, widely used as an index of the intrusive (peak-traffic) noise, is denoted: **[2 marks]**

(A) $L_{eq}$

(B) $L_{10}$

(C) $L_{90}$

(D) $L_{max}$

## Solid and Hazardous Waste Management

**Q35.** A city has a population of $300{,}000$ and a per-capita municipal solid-waste (MSW) generation rate of $0.6$ kg/person/day. The total MSW generated per day, expressed in tonnes, is: **[2 marks]**

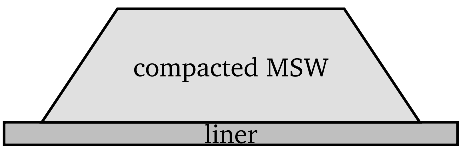
(A) 600 tonnes/day

(B) 60 tonnes/day

(C) 300 tonnes/day

(D) 180 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$^3$

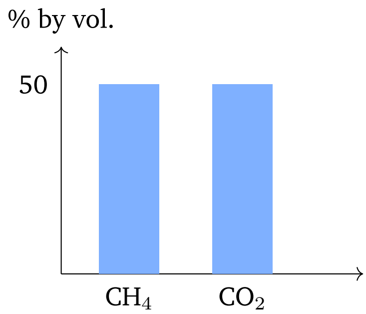
(A) $91{,}250$ m$^3$

(B) 45,625 $m^3$

(C) 22,812 $m^3$

(D) 182,500 $m^3$

**Q37.** A closed sanitary landfill generates gas that is approximately 50% methane and 50% carbon dioxide by volume. If the total landfill-gas generation is 200 $m^3$/day, the volume of methane (the energy-recoverable fraction) generated per day is: **[2 marks]**




(A) 200 $m^3$/day

(B) 50 $m^3$/day

(C) 150 $m^3$/day

(D) 100 $m^3$/day

**Q38.** In a sanitary landfill, the contaminated liquid that must be collected and treated is the leachate. Leachate is best described as: **[2 marks]**

(A) the gas generated by decomposition of the waste

(B) the contaminated liquid that forms as water percolates through and drains from the waste mass

(C) the compacted soil placed as daily cover

(D) the treated effluent leaving a sewage-treatment plant

**Q39.** A mass-burn incinerator receives 200 tonnes/day of MSW and leaves an ash residue equal to 25% of the input mass. The mass of ash (bottom + fly ash) produced per day is: **[2 marks]**

(A) 150 tonnes/day

(B) 50 tonnes/day

(C) 200 tonnes/day

(D) 25 tonnes/day

**Q40.** During the stable methanogenic phase of decomposition inside a sanitary landfill, the two principal gases generated are: **[2 marks]**

(A) methane and carbon dioxide

(B) oxygen and nitrogen

(C) hydrogen sulphide and ammonia only

(D) ozone and chlorofluorocarbons

## Environmental Management, Sustainability and Climate

**Q41.** A cradle-to-grave study that quantifies the total environmental burden of a product over all stages, raw-material extraction, manufacture, use and final disposal, is called the: **[2 marks]**

(A) Environmental Impact Assessment

(B) Environmental Management Plan

(C) Detailed Project Report

(D) Life Cycle Assessment

**Q42.** Over a 100-year time horizon, the approximate global-warming potential (GWP) of methane ($CH_4$) relative to carbon dioxide ($CO_2 = 1$) is closest to: **[2 marks]**

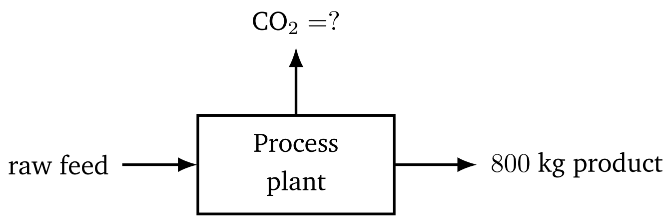
(A) 1

(B) 9

(C) 28

(D) 0.5

**Q43.** For the process shown, a plant emits 1.5 kg of $CO_2$ for every kilogram of product and manufactures 800 kg of product each day. The daily $CO_2$ emission, obtained from the mass balance, is: **[2 marks]**




(A) 1.2 tonnes/day

(B) 800 kg/day

(C) 0.8 tonne/day

(D) 2.4 tonnes/day

**Q44.** The Human Development Index (HDI), a composite indicator often cited in discussions of sustainable development, combines which three dimensions? **[2 marks]**

(A) rainfall, temperature and humidity

(B) gross domestic product alone

(C) a long and healthy life, knowledge (education) and a decent standard of living

(D) military strength, population and land area

**Q45.** The international agreement adopted in 2015 under the UNFCCC, which aims to hold the increase in global average temperature to well below 2°C above pre-industrial levels, is the: **[2 marks]**

(A) Paris Agreement

(B) Montreal Protocol

(C) Ramsar Convention

(D) Basel Convention

**Q46.** The ecological footprint, used as a sustainability indicator, is a measure of: **[2 marks]**

(A) the total mass of carbon dioxide present in the atmosphere

(B) the biologically productive land and water area required to supply a population's resource consumption and absorb its wastes

(C) the number of species present in an ecosystem

(D) the depth of the groundwater table below the surface

# Detailed Solutions

## Q1.

**Solution**

**Concept – pH from the hydroxyl-ion concentration:** At $25°C$, pH and pOH are linked by $pH + pOH = 14$, and $pOH = -\log_{10}[OH^-]$.

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

**Step 2 – find pOH:** $pOH = -\log_{10}(1 \times 10^{-4})$

**Step 3 – apply the logarithm:** $\log_{10}(10^{-4}) = -4$, so $pOH = 4$

**Step 4 – convert to pH:** $pH = 14 - pOH = 14 - 4$

$pH = 10$

**Step 5 – interpret:** A pH of $10$ is above $7$, so the water is basic, consistent with a high $[OH^-]$.

**Final Answer:** $pH = 10 \Rightarrow \boxed{A}$

**Answer: (A)** Go Back to Q1

## Q2.

**Solution**

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

**Step 1 – equivalent weight of calcium:** Calcium has valency $2$, so its equivalent weight is $\frac{40}{2} = 20$

**Step 2 – form the conversion factor:** factor $= \frac{50}{20} = 2.5$

**Step 3 – multiply the calcium concentration by the factor:** Hardness $= 40 \times 2.5$

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

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

**Answer: (C)** Go Back to Q2

## Q3.

**Solution**

**Concept – carbonate and non-carbonate hardness:** Carbonate (temporary) hardness is the part of total hardness that is balanced by alkalinity. When total hardness exceeds alkalinity, carbonate hardness equals the alkalinity and the remainder is non-carbonate (permanent) hardness.

**Step 1 – list the data:** Total hardness $TH = 250$ mg/L, total alkalinity $= 180$ mg/L (both as $CaCO_3$).

**Step 2 – test which is larger:** $TH = 250 >$ alkalinity $= 180$, so carbonate hardness $=$ alkalinity $= 180$ mg/L.

**Step 3 – non-carbonate hardness:** NCH $= TH -$ carbonate hardness

**Step 4 – substitute:** NCH $= 250 - 180$

NCH $= 70$ mg/L as $CaCO_3$

**Final Answer:** $70$ mg/L as $CaCO_3 \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q3

## Q4.

**Solution**

**Concept – alkalinity expressed as $CaCO_3$:** An ion's contribution to alkalinity, expressed as $CaCO_3$, equals its concentration times $\dfrac{\text{eq. wt. of } CaCO_3}{\text{eq. wt. of the ion}} = \dfrac{50}{\text{eq. wt. of the ion}}$.

**Step 1 – equivalent weight of bicarbonate:** $HCO_3^-$ has molar mass $61$ and valency $1$, so its equivalent weight is $\dfrac{61}{1} = 61$

**Step 2 – form the conversion factor:** factor $= \dfrac{50}{61}$

**Step 3 – multiply the bicarbonate concentration by the factor:** Alkalinity $= 61 \times \dfrac{50}{61}$

**Step 4 – the $61$ cancels:** Alkalinity $= 50$ mg/L as $CaCO_3$

**Final Answer:** $50$ mg/L as $CaCO_3 \Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q4

## Q5.

### Solution

**Concept – biological nitrification:** Nitrification is a two-step aerobic oxidation of reduced nitrogen carried out by chemoautotrophic bacteria that use the reaction for energy.

**Step 1 – first step (*Nitrosomonas*):** Ammonium is oxidised to nitrite: $NH_4^+ \rightarrow NO_2^-$.

**Step 2 – second step (*Nitrobacter*):** Nitrite is oxidised to nitrate: $NO_2^- \rightarrow NO_3^-$.

**Step 3 – combine:** Overall the pathway is ammonium $\rightarrow$ nitrite $\rightarrow$ nitrate, matching option C.

**Why the other options are wrong:**

- A, oxidising organic carbon: describes heterotrophic BOD removal, not nitrification.
- B, sulphate to sulphide: is anaerobic sulphate reduction.
- D, methane to $CO_2$: is methanotrophic oxidation, unrelated to nitrogen.

**Final Answer:** ammonium to nitrite and nitrite to nitrate $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q5

## Q6.

### Solution

**Concept – standard BOD test conditions:** The standard BOD determination fixes both the incubation period and the temperature so that results are comparable.

**Step 1 – recall the incubation period:** The sample is incubated for $5$ days, giving the commonly reported $BOD_5$.

**Step 2 – recall the temperature:** Incubation is carried out at $20°C$ in the dark to prevent algal photosynthesis.

**Step 3 – combine:** The standard conditions are therefore $5$ days at $20°C$, matching option D.

**Why the other options are wrong:**

- A, B and C: use non-standard periods or temperatures and are not the accepted $BOD_5$ convention.

**Final Answer:** $5$ days at $20°C \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q6

## Q7.

**Solution**

**Concept – reservoir storage balance:** Over a period the change in stored volume equals what comes in minus everything that leaves, $\Delta S = \text{inflow} - \text{losses} - \text{draft}$.

**Step 1 – list the data:** inflow $= 120$ Mm$^3$, losses $= 30$ Mm$^3$, draft $= 70$ Mm$^3$.

**Step 2 – write the balance:** $\Delta S = 120 - 30 - 70$

**Step 3 – subtract the losses:** $120 - 30 = 90$

**Step 4 – subtract the draft:** $90 - 70 = 20$

$\Delta S = +20$ Mm$^3$, a net increase in storage.

**Final Answer:** $\Delta S = +20\ \text{Mm}^3 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q7

## Q8.

**Solution**

**Concept – rational formula for peak runoff:** $Q = \dfrac{C\,i\,A}{360}$ gives $Q$ in m$^3$/s when $i$ is in mm/hr and $A$ in hectares.

**Step 1 – list the data:** $C = 0.5$, $i = 72$ mm/hr, $A = 50$ ha.

**Step 2 – form the numerator:** $C\,i\,A = 0.5 \times 72 \times 50$

**Step 3 – multiply step by step:** $0.5 \times 72 = 36$

$36 \times 50 = 1800$

**Step 4 – divide by** $360$**:** $Q = \dfrac{1800}{360}$

$Q = 5$ m$^3$/s

**Final Answer:** $Q = 5\ \text{m}^3/\text{s} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

## Q9.

**Solution**

**Concept – Darcy's law:** The specific discharge (Darcy velocity) is the product of hydraulic conductivity and hydraulic gradient, $v = K\,i$.

**Step 1 – list the data:** $K = 15$ m/day, $i = 0.04$.

**Step 2 – substitute:** $v = 15 \times 0.04$

**Step 3 – evaluate:** $v = 0.6$ m/day

**Final Answer:** $v = 0.6$ m/day $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q9

## Q10.

**Solution**

**Concept – Darcy discharge through an aquifer section:** The flow equals the Darcy velocity times the cross-sectional area, $Q = K\,i\,(b\,W)$, where $b\,W$ is the area normal to flow.

**Step 1 – list the data:** $K = 30$ m/day, $i = 0.002$, $b = 15$ m, $W = 500$ m.

**Step 2 – compute the cross-sectional area:** $A = b\,W = 15 \times 500 = 7500$ m$^2$

**Step 3 – compute the Darcy velocity:** $v = K\,i = 30 \times 0.002 = 0.06$ m/day

**Step 4 – multiply velocity by area:** $Q = 0.06 \times 7500$

$Q = 450$ m$^3$/day

**Final Answer:** $Q = 450$ m$^3$/day $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q10

## Q11.

**Solution**

**Concept – linearity 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 is scaled by $P$ (principle of proportionality).

**Step 1 – list the data:** Unit-hydrograph peak $= 25$ m$^3$/s, rainfall excess $P = 3$ cm.

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

**Step 3 – substitute:** $Q_{peak} = 3 \times 25$

**Step 4 – evaluate:** $Q_{peak} = 75$ m$^3$/s

**Final Answer:** $Q_{peak} = 75\ \text{m}^3/\text{s} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q11

## Q12.

**Solution**

**Concept – Manning's velocity equation:** $V = \dfrac{1}{n} R^{2/3} S^{1/2}$.

**Step 1 – list the data:** $n = 0.013$, $R = 1$ m, $S = 0.0001$.

**Step 2 – evaluate $R^{2/3}$:** $R^{2/3} = 1^{2/3} = 1$

**Step 3 – evaluate $S^{1/2}$:** $S^{1/2} = \sqrt{0.0001} = 0.01$

**Step 4 – form the coefficient:** $\dfrac{1}{n} = \dfrac{1}{0.013} = 76.9$

**Step 5 – multiply the three factors:** $V = 76.9 \times 1 \times 0.01$

$V \approx 0.77$ m/s

**Final Answer:** $V \approx 0.77\ \text{m/s} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q12

## Q13.

**Solution**

**Concept – arithmetic-increase method of population forecast:** Population grows by a constant amount each decade, so $P_n = P_0 + n\,\overline{x}$, where $\overline{x}$ is the average decadal increase and $n$ the number of decades.

**Step 1 – count the decades from $2020$ to $2040$:** $n = \dfrac{2040 - 2020}{10} = 2$ decades

**Step 2 – compute the total increase:** $n\,\overline{x} = 2 \times 8000 = 16000$

**Step 3 – add to the base population:** $P = 60000 + 16000$

$P = 76000$

**Final Answer:** $P = 76{,}000 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q13

## Q14.

### Solution

**Concept – average daily water demand:** Total demand equals per-capita demand times population.

**Step 1 – list the data:** Per-capita demand $= 150$ L/person/day, population $=$ $200000$.

**Step 2 – multiply:** Demand $= 150 \times 200000$

**Step 3 – evaluate in litres per day:** Demand $= 30{,}000{,}000$ L/day

**Step 4 – convert to million litres per day:** Demand $= \dfrac{30{,}000{,}000}{10^6} = 30$ MLD

**Final Answer:** $30$ MLD $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q14

## Q15.

### Solution

**Concept – surface overflow rate:** The surface overflow rate (surface loading) of a settling tank is the flow divided by the plan area, $SOR = Q/A$, and has units of velocity.

**Step 1 – list the data:** $Q = 6000$ m$^3$/day, $A = 300$ m$^2$.

**Step 2 – write the relation:** $SOR = \dfrac{Q}{A}$

**Step 3 – substitute:** $SOR = \dfrac{6000}{300}$

**Step 4 – evaluate:** $SOR = 20$ m$^3$/m$^2$/day $= 20$ m/day

**Final Answer:** $SOR = 20$ m/day $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q15

## Q16.

### Solution

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

**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:** $g(\rho_s - \rho)d^2 = 9.81 \times 1600 \times 4 \times 10^{-10}$

$9.81 \times 1600 = 15696$

$15696 \times 4 \times 10^{-10} = 6.28 \times 10^{-6}$

**Step 4 – form the denominator:** $18\mu = 18 \times 1.0 \times 10^{-3} = 0.018$

**Step 5 – divide:** $v_s = \dfrac{6.28 \times 10^{-6}}{0.018}$

$v_s \approx 3.5 \times 10^{-4}$ m/s

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

Answer: (B) Go Back to Q16

## Q17.

### Solution

**Concept – aeration for iron and manganese removal:** Dissolved iron in groundwater is present as soluble ferrous ($Fe^{2+}$) ions. Aeration supplies oxygen that oxidises it.

**Step 1 – what aeration does chemically:** $Fe^{2+}$ is oxidised to $Fe^{3+}$, which precipitates as insoluble ferric hydroxide $Fe(OH)_3$.

**Step 2 – why this helps treatment:** The insoluble ferric floc can then be removed by sedimentation and filtration, lowering the iron content.

**Step 3 – match the option:** This is exactly option A.

**Why the other options are wrong:**

- B, adding fluoride: is fluoridation, a separate dosing step.
- C, increasing hardness: aeration does not add hardness ions.
- D, lowering pH: aeration usually strips $CO_2$ and tends to raise pH, not sharply lower it.

**Final Answer:** oxidise ferrous iron to the insoluble ferric form $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q17

## Q18.

**Solution**

**Concept – chlorine demand:** The chlorine demand is the amount of chlorine consumed by reaction with impurities; it equals the applied dose minus the measured residual, demand = dose − residual.

**Step 1 – list the data:** dose $= 3.0$ mg/L, residual $= 0.4$ mg/L.

**Step 2 – write the relation:** demand = dose − residual

**Step 3 – substitute:** demand $= 3.0 - 0.4$

**Step 4 – evaluate:** demand $= 2.6$ mg/L

**Final Answer:** chlorine demand $= 2.6$ mg/L $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q18

## Q19.

**Solution**

**Concept – BOD-removal efficiency:** Removal efficiency is the fraction of BOD removed, $\eta = \dfrac{S_0 - S_e}{S_0} \times 100\%$.

**Step 1 – list the data:** influent BOD $S_0 = 250$ mg/L, effluent BOD $S_e = 25$ mg/L.

**Step 2 – compute the BOD removed:** $S_0 - S_e = 250 - 25 = 225$ mg/L

**Step 3 – divide by the influent value:** $\eta = \dfrac{225}{250}$

**Step 4 – convert to per cent:** $\eta = 0.90 \times 100 = 90\%$

**Final Answer:** $\eta = 90\% \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q19

## Q20.

**Solution**

**Concept – products of anaerobic digestion:** Anaerobic digestion stabilises sludge in the absence of oxygen. Its final, gas-forming stage is methanogenesis.

**Step 1 – recall the methanogenic stage:** Methanogenic archaea convert simple acids (mainly acetic acid) and $H_2/CO_2$ into gas.

**Step 2 – identify the gases:** The biogas produced is chiefly methane ($CH_4$, roughly 60–70%) and carbon dioxide ($CO_2$).

**Step 3 – match the option:** Methane and carbon dioxide is option D.

**Why the other options are wrong:**

- A, oxygen and nitrogen: oxygen cannot be present in an anaerobic reactor.
- B, hydrogen and oxygen: hydrogen is an intermediate, but free oxygen is absent.
- C, ammonia and chlorine: not the principal digester gases.

**Final Answer:** methane and carbon dioxide $\Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q20

## Q21.

**Solution**

**Concept – first-order BOD exertion:** The BOD exerted by time $t$ follows $y_t = L_0\left(1 - e^{-kt}\right)$, with $k$ to base $e$.

**Step 1 – list the data:** $L_0 = 250$ mg/L, $k = 0.23$ day$^{-1}$, $t = 5$ days.

**Step 2 – compute the exponent:** $kt = 0.23 \times 5 = 1.15$

**Step 3 – evaluate $e^{-kt}$:** $e^{-1.15} \approx 0.3166$

**Step 4 – form the bracket:** $1 - 0.3166 = 0.6834$

**Step 5 – multiply by $L_0$:** $y_5 = 250 \times 0.6834$

$y_5 \approx 171$ mg/L

**Final Answer:** $y_5 \approx 171$ mg/L $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q21

## Q22.

**Solution**

**Concept – food-to-microorganism ratio:** $F/M = \dfrac{Q\,S_0}{V\,X}$, the mass of BOD applied per day per unit mass of micro-organisms held in the tank.

**Step 1 – list the data:** $Q = 1600$ m$^3$/day, $S_0 = 250$ mg/L, $V = 800$ m$^3$, $X = 2500$ mg/L.

**Step 2 – form the numerator:** $Q\,S_0 = 1600 \times 250 = 400000$

**Step 3 – form the denominator:** $V\,X = 800 \times 2500 = 2000000$

**Step 4 – divide:** $F/M = \dfrac{400000}{2000000}$

$F/M = 0.2$ per day

**Step 5 – note on units:** Because both concentrations are in mg/L, the units cancel and the ratio has dimension per day.

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

**Answer: (B)** Go Back to Q22

## Q23.

### Solution

**Concept – biogas yield from volatile-solids destruction:** The gas produced equals the mass of volatile solids destroyed times the specific gas yield.

**Step 1 – list the data:** VS destroyed $= 1000$ kg/day, gas yield $= 0.9$ m$^3$/kg VS.

**Step 2 – write the relation:** Gas $=$ (VS destroyed) $\times$ (yield)

**Step 3 – substitute:** Gas $= 1000 \times 0.9$

**Step 4 – evaluate:** Gas $= 900$ m$^3$/day

**Final Answer:** $900$ m$^3$/day $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q23

## Q24.

### Solution

**Concept – complete-mixing (mass-balance) concentration:** When two streams mix fully, the resulting concentration is the flow-weighted average, $C_{mix} = \dfrac{Q_wC_w + Q_rC_r}{Q_w + Q_r}$.

**Step 1 – list the data:** $Q_w = 1$ m$^3$/s, $C_w = 180$ mg/L, $Q_r = 9$ m$^3$/s, $C_r = 3$ mg/L.

**Step 2 – compute the load from each stream:** $Q_wC_w = 1 \times 180 = 180$

$Q_rC_r = 9 \times 3 = 27$

**Step 3 – add the loads:** $180 + 27 = 207$

**Step 4 – add the flows:** $Q_w + Q_r = 1 + 9 = 10$ m$^3$/s

**Step 5 – divide:** $C_{mix} = \dfrac{207}{10} = 20.7$ mg/L

**Final Answer:** $C_{mix} \approx 20.7$ mg/L $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q24

## Q25.

**Solution**

**Concept – terminal settling velocity in a gravity chamber:** For a small particle in the Stokes 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:** $g\,\rho_p\,d^2 = 9.81 \times 2500 \times 9 \times 10^{-10}$

$9.81 \times 2500 = 24525$

$24525 \times 9 \times 10^{-10} = 2.207 \times 10^{-5}$

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

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

$v_t \approx 0.068$ m/s

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

**Answer: (B)** Go Back to Q25

## Q26.

**Solution**

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

**Step 1 – list the data:** inlet loading $C_{in} = 12$ g/m$^3$, outlet loading $C_{out} = 1.2$ g/m$^3$.

**Step 2 – compute the mass removed:** $C_{in} - C_{out} = 12 - 1.2 = 10.8$ g/m$^3$

**Step 3 – divide by the inlet loading:** $\eta = \dfrac{10.8}{12}$

**Step 4 – convert to per cent:** $\eta = 0.90 \times 100 = 90\%$

**Final Answer:** $\eta = 90\% \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q26

## Q27.

**Solution**

**Concept – Gaussian plume, ground-level source:** 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, $u = 4$ m/s, $\sigma_y = 40$ m, $\sigma_z = 20$ m.

**Step 2 – form the denominator:** $\pi\,\sigma_y\,\sigma_z\,u = \pi \times 40 \times 20 \times 4$

$40 \times 20 = 800$

$800 \times 4 = 3200$

$\pi \times 3200 \approx 10053$

**Step 3 – divide:** $C = \dfrac{120}{10053}$

$C \approx 0.01194$ g/m$^3$

**Step 4 – convert to mg/m$^3$:** $C \approx 11.9$ 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 adds the plume rise to the physical stack height, $H = h + \Delta h$.

**Step 1 – list the data:** $h = 45$ m, $\Delta h = 20$ m.

**Step 2 – write the relation:** $H = h + \Delta h$

**Step 3 – substitute:** $H = 45 + 20$

**Step 4 – evaluate:** $H = 65$ m

**Final Answer:** $H = 65$ m $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q28

## Q29.

**Solution**

**Concept – environmental (normal) lapse rate:** The environmental lapse rate is the observed decrease of air temperature with height in the real atmosphere, averaged over many conditions.

**Step 1 – recall the standard value:** The average environmental lapse rate is about 6.5°C per kilometre.

**Step 2 – distinguish from the adiabatic rate:** This differs from the dry adiabatic lapse rate ($\approx 9.8$°C/km), which applies to a rising dry parcel, not to the ambient profile.

**Why the other options are wrong:**

- A, 9.8°C/km: is the dry adiabatic lapse rate.
- C, 0.98°C/km and D, 1.0°C/km: are off by an order of magnitude.

**Final Answer:** $\approx 6.5$°C/km $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q29

## Q30.

### Solution

**Concept – converting ppm (by volume) to mass concentration:** $\mu\text{g/m}^3 = \text{ppm} \times \dfrac{M}{24.45} \times 1000$, where $M$ is the molecular mass and 24.45 L is the molar volume at 25°C, 1 atm.

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

**Step 2 – form the ratio $M/24.45$:** $\dfrac{46}{24.45} \approx 1.881$

**Step 3 – multiply by the ppm value:** $0.05 \times 1.881 = 0.09407$

**Step 4 – multiply by 1000:** $0.09407 \times 1000 \approx 94\ \mu\text{g/m}^3$

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

**Answer: (C)** Go Back to Q30

## Q31.

### Solution

**Concept – adding sound levels on an energy basis:** Sound levels add through their intensities, $L = 10\log_{10}\left(10^{L_1/10} + 10^{L_2/10}\right)$. Two equal sources give a rise of $10\log_{10}2 \approx 3$ dB.

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

**Step 2 – write the sum of intensities:** $L = 10\log_{10}(10^{8.5} + 10^{8.5})$

**Step 3 – factor the equal terms:** $L = 10\log_{10}(2 \times 10^{8.5})$

**Step 4 – split the logarithm:** $L = 10\,(\log_{10}2 + 8.5) = 10(0.301 + 8.5)$

**Step 5 – evaluate:** $L = 10 \times 8.801 = 88.0$ dB

**Why the other options are wrong:**

- B, 170 dB: wrongly adds the decibel numbers arithmetically.
- C, 85 dB: ignores the second source.
- D, 91 dB: assumes a 6 dB rise, which applies to coherent pressure doubling, not energy addition.

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

Answer: (A) Go Back to Q31

## Q32.

### Solution

**Concept – OSHA permissible exposure and the 5-dB exchange rate:** Under the OSHA rule, 90 dBA is allowed for 8 hours, and the permissible time halves for each 5 dBA rise in level.

**Step 1 – find the level increase:** $95 - 90 = 5$ dBA, which is exactly one exchange step.

**Step 2 – apply the halving:** Allowed time $= \frac{8}{2} = 4$ hours.

**Step 3 – state the result:** At 95 dBA the permissible daily exposure is 4 hours.

**Why the other options are wrong:**

- A, 8 hours: is the limit at 90 dBA, not 95.
- B, 2 hours: corresponds to 100 dBA (two halvings).
- C, 1 hour: corresponds to 105 dBA.

**Final Answer:** 4 hours $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q32

## Q33.

### Solution

**Concept – inverse-square (distance) attenuation of a point source:** In a free field the level of a point source drops by 6 dB for every doubling of distance.

**Step 1 – count the doublings from 5 m to 20 m:** $5 \rightarrow 10$ m is one doubling; $10 \rightarrow 20$ m is a second doubling, so 2 doublings in all.

**Step 2 – total attenuation:** $2 \times 6 = 12$ dB

**Step 3 – subtract from the near level:** $L = 95 - 12$

$L = 83$ dB

**Step 4 – cross-check with the formula:** $L = 95 - 20\log_{10}(20/5) = 95 - 20\log_{10} 4 = 95 - 12.04 \approx 83$ dB. Consistent.

**Final Answer:** $L = 83$ dB $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q33

## Q34.

### Solution

**Concept – statistical noise descriptors:** The percentile levels $L_n$ give the A-weighted level exceeded for $n\%$ of the measurement time.

**Step 1 – interpret $L_{10}$:** $L_{10}$ is the level exceeded $10\%$ of the time, representing the higher, intrusive noise (for example peak traffic).

**Step 2 – match the description:** The index used for intrusive/peak noise is therefore $L_{10}$.

**Why the other options are wrong:**

- A, $L_{eq}$: is the equivalent continuous energy-average level, not a percentile.
- C, $L_{90}$: is exceeded $90\%$ of the time and represents the background noise.
- D, $L_{max}$: is the single highest instantaneous level.

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

**Answer: (B)** Go Back to Q34

## Q35.

### Solution

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

**Step 1 – list the data:** population $= 300000$, rate $= 0.6$ kg/person/day.

**Step 2 – multiply:** MSW $= 0.6 \times 300000$

**Step 3 – evaluate in kilograms:** MSW $= 180000$ kg/day

**Step 4 – convert to tonnes:** MSW $= \dfrac{180000}{1000} = 180$ tonnes/day

**Final Answer:** 180 tonnes/day $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q35

## Q36.

### Solution

**Concept – landfill airspace from mass and density:** Required volume equals the mass of compacted waste divided by its in-place density, $V = m/\rho$.

**Step 1 – annual mass of waste:** $m = 150$ tonnes/day $\times$ 365 days $=$ 54750 tonnes

**Step 2 – convert tonnes to kilograms:** $m = 54750 \times 1000 = 5.475 \times 10^7$ kg

**Step 3 – divide by the in-place density:** $V = \dfrac{5.475 \times 10^7}{600}$

**Step 4 – evaluate:** $V = 91250\ \text{m}^3$

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

Answer: (A) Go Back to Q36

## Q37.

### Solution

**Concept – methane fraction of landfill gas:** Landfill gas in the stable phase is roughly half methane and half carbon dioxide by volume, so the methane volume is that fraction of the total.

**Step 1 – list the data:** total gas $= 200\ \text{m}^3$/day, methane fraction $= 50\% = 0.5$.

**Step 2 – multiply the total by the fraction:** $V_{\text{CH}_4} = 0.5 \times 200$

**Step 3 – evaluate:** $V_{\text{CH}_4} = 100\ \text{m}^3/\text{day}$

**Final Answer:** $100\ \text{m}^3/\text{day} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q37

## Q38.

### Solution

**Concept – definition of leachate:** Leachate is the liquid that has percolated through a waste mass and picked up dissolved and suspended contaminants.

**Step 1 – recall how leachate forms:** Rainfall and moisture infiltrate the landfill, pass through the decomposing waste and dissolve organic and inorganic pollutants.

**Step 2 – match the option:** This contaminated draining liquid is described by option B.

**Why the other options are wrong:**

- A: describes landfill gas, not a liquid.
- C: is the daily soil cover, a solid.
- D: is treated sewage effluent, unrelated to a landfill.

**Final Answer:** the contaminated liquid that drains from the waste mass $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q38

## Q39.

### Solution

**Concept – ash residue from incineration:** The ash mass equals the input MSW mass times the residue fraction.

**Step 1 – list the data:** input $= 200$ tonnes/day, ash fraction $= 25\% = 0.25$.

**Step 2 – multiply:** ash $= 0.25 \times 200$

**Step 3 – evaluate:** ash $= 50$ tonnes/day

**Final Answer:** $50$ tonnes/day $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q39

## Q40.

### Solution

**Concept – methanogenic-phase landfill gas:** Once oxygen is exhausted and the landfill turns anaerobic, methanogens dominate and generate the mature landfill gas.

**Step 1 – recall the stable-phase products:** The two principal gases are methane ($CH_4$) and carbon dioxide ($CO_2$), roughly in a $1{:}1$ volume ratio.

**Step 2 – match the option:** Methane and carbon dioxide is option A.

**Why the other options are wrong:**

- B, oxygen and nitrogen: are consumed/displaced early; the stable phase is anaerobic.
- C, $H_2S$ and ammonia: occur only as trace odour gases, not the principal products.

- D, ozone and CFCs: are not generated by waste decomposition.

**Final Answer:** methane and carbon dioxide $\Rightarrow \boxed{A}$

**Answer: (A)** Go Back to Q40

## Q41.

### Solution

**Concept – Life Cycle Assessment:** A Life Cycle Assessment (LCA) evaluates the environmental burdens of a product from raw-material extraction through manufacture, use and disposal (cradle to grave).

**Step 1 – match the description:** The study spanning all life stages of a product is the LCA, option D.

**Why the other options are wrong:**

- A, EIA: assesses a specific project/site, not a product across its life cycle.
- B, EMP: is the plan to manage and mitigate a project's impacts during operation.
- C, DPR: is an engineering/financial project report, not an environmental burden study.

**Final Answer:** Life Cycle Assessment $\Rightarrow \boxed{D}$

**Answer: (D)** Go Back to Q41

## Q42.

### Solution

**Concept – global-warming potential (GWP):** GWP compares the heat trapped by a gas over a chosen horizon to that trapped by the same mass of $CO_2$ (defined as 1).

**Step 1 – recall methane's 100-year GWP:** Methane traps far more heat per unit mass than $CO_2$; over 100 years its GWP is about 28 (roughly 28–30 in recent assessments).

**Step 2 – select the nearest value:** Among the options, 28 is the correct order of magnitude.

**Why the other options are wrong:**

- A, 1: is $CO_2$ itself.

- B, 9: understates methane's effect.
- D, 0.5: would make methane weaker than $CO_2$, which is false.

**Final Answer:** $\approx 28 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q42

## Q43.

### Solution

**Concept – emission mass balance:** Daily emission equals the emission factor times the daily production.

**Step 1 – list the data:** emission factor $= 1.5$ kg $CO_2$/kg product, production $= 800$ kg/day.

**Step 2 – multiply:** $CO_2 = 1.5 \times 800$

**Step 3 – evaluate in kilograms:** $CO_2 = 1200$ kg/day

**Step 4 – convert to tonnes:** $CO_2 = \dfrac{1200}{1000} = 1.2$ tonnes/day

**Final Answer:** $1.2$ tonnes/day $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q43

## Q44.

### Solution

**Concept – Human Development Index:** The HDI is a composite index built from three dimensions of human well-being.

**Step 1 – recall the three dimensions:** (i) a long and healthy life (life expectancy), (ii) knowledge (education/schooling) and (iii) a decent standard of living (income per capita).

**Step 2 – match the option:** These three together are stated in option C.

**Why the other options are wrong:**

- A: lists weather variables, not development indicators.
- B: uses income alone, ignoring health and education.
- D: lists military/geographic factors, which are not part of HDI.

**Final Answer:** health, education and standard of living $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q44

## Q45.

### Solution

**Concept – the Paris Agreement:** Adopted in 2015 under the UNFCCC, the Paris Agreement sets a global goal to limit warming to well below 2°C (pursuing 1.5°C) above pre-industrial levels.

**Step 1 – match the description:** The 2015 climate treaty with the below-2°C target is the Paris Agreement, option A.

**Why the other options are wrong:**

- B, Montreal Protocol (1987): phases out ozone-depleting substances, not a temperature target.
- C, Ramsar Convention: protects wetlands.
- D, Basel Convention: controls trans-boundary movement of hazardous wastes.

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

**Answer: (A)** Go Back to Q45

## Q46.

### Solution

**Concept – the ecological footprint:** The ecological footprint expresses human demand on nature as the biologically productive land and water area needed to provide resources and absorb wastes.

**Step 1 – recall the definition:** It measures the productive area required to support a population's consumption and to assimilate its wastes (for example $CO_2$ uptake), usually in global hectares.

**Step 2 – match the option:** This is option B.

**Why the other options are wrong:**

- A: total atmospheric $CO_2$ is a stock, not an area-based demand indicator.
- C: number of species is a biodiversity measure.
- D: groundwater depth is a hydrogeological parameter.

**Final Answer:** the productive land/water area needed to support consumption and absorb wastes $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q46

## Answer Key

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