

ES: Environmental Science and Engineering

Section 1: Mathematics Foundation

Linear Algebra: Determinants and matrices, Systems of linear equations, Eigenvalues and eigenvectors.

Calculus: Functions, Limit, Continuity, Differentiability, Local maxima and minima, Taylor series, Tests for convergence, Definite and indefinite integrals, Application of definite integral to obtain area and volume, Partial and total derivatives.

Differential Equations: Linear and non-linear first order ordinary differential equations (ODE), Higher order linear ODEs with constant coefficients, Cauchy's and Euler's equations, Laplace transform and its application in solving linear ODEs.

Probability and Statistics: Descriptive statistics, Measurement of central tendency, Dispersion, Skewness and kurtosis, Probability concepts, Conditional probability, Bayes theorem, Risk and reliability, Probability distributions, Correlation, Single and multiple regression models, Hypothesis testing (t-test, F-test, chi-square test).

Section 2: Environmental Chemistry

Fundamentals of Environmental Chemistry: Covalent and ionic bonding; Chemical equations, concentration and activity; Structure and chemistry of organic molecules; Radioactivity of elements; Chemical equilibria; Thermodynamics and kinetics of chemical reactions.

Principles of water chemistry: Water quality parameters and their measurement; Acid-base equilibria; Buffer solution; Carbonate system; Solubility of gases in water; Complexation, precipitation, and redox reactions; Inorganic and organic contaminants in water and their speciation.

Soil chemistry; Organic matter, nitrogen, phosphorous, potassium, cation exchange capacity, base saturation, and sodium absorption ratio.

Atmospheric Chemistry: Composition of the atmosphere; Reactivity of trace substances in the atmosphere; Urban atmosphere—smog and particulate pollution; Chemistry of ozone formation; Chemistry of stratosphere.

Section 3: Environmental Microbiology

Prokaryotic and eukaryotic microorganisms; Characteristics of diverse groups of microorganisms; Classification of microorganisms; Microbial diversity; Plant-microbe and soil-microbe interactions; Role of microorganisms in wastewater treatment, bioremediation and biogeochemical cycling.

Cell chemistry and cell biology: Structure of proteins, nucleic acid (DNA & RNA), lipids and polysaccharides; Bonds in biomolecules; Stereoisomerism in biomolecules; Structure of cell; Structure and function of cytoplasmic membrane, cell wall, outer membrane, glycocalyx, chromosomes, endospores, storage products, mitochondria and chloroplasts.

Microbial metabolism: Anabolism and catabolism; Phosphorylation; Glycolysis; TCA cycle; Electron transport chain; Fermentation; Anaerobic respiration; Energy balances; Enzymes and Enzyme kinetics.

Growth and control of microorganisms: Bacterial nutrition and growth; Specific growth rate and doubling time; Monod's model; Types of culture media; Batch and continuous culture; Effects of environmental factors on growth; Control of microbes using physical and chemical methods.

Microbiology and health: Pathogens and modes of transmission; Indicator organisms; Quantification of coliforms using MPN and membrane filtration techniques.

Section 4: Water Resources and Environmental Hydraulics

Global Water Resources: Structure, properties and distribution of water; Water quality; Threats to water resources; Water conservation.

Surface Water Resources: Hydrological cycle and water balance - precipitation, infiltration, evapotranspiration, runoff; Flow hydrographs; Unit hydrographs; Stage-discharge relationship; Reservoir capacity; Reservoir and channel routing; Surface run-off models; Surface water management; Rain water harvesting and storage.

Groundwater Resources: Geologic formations as aquifers; Vadose and saturated zones; Confined and unconfined aquifers and their parameters - porosity, permeability, transmissivity and storage coefficient; Darcy's law and applications; Steady state well hydraulics.

Environmental Hydraulics: Concepts of mechanics; Properties of fluids; Pressure measurement; Hydrostatic force on surfaces; Buoyancy and flotation; Laminar and turbulent flow; Flow through pipes; Pipe networks; Boundary layer theory; Forces on immersed bodies; Flow measurement in channels and pipes; Kinematics of flow; Continuity, momentum and energy equations; Channel hydraulics - specific energy, critical flow, hydraulic jump, rapid and gradually varied flow; Design of lined and unlined channels.

Section 5: Water & Wastewater Treatment and Management

Water and wastewater quality parameters; Eutrophication and thermal stratification in lakes; River pollution - Oxygen sag curve.

Water treatment methods - screening, sedimentation with and without coagulation, filtration, desalination, disinfection; Water distribution and storage

Point and non-point sources of wastewater; Population forecasting methods; Design of sewer and storm water sewers; Sewer appurtenances; Preliminary, primary, secondary and tertiary sewage treatment; Sludge generation, processing and disposal methods; Sewage farming.

Sources and characteristics of industrial effluents; Concept of Common Effluent Treatment Plants (CETP); Wastewater recycling and zero liquid discharge.

Kinetics and reactor design: Mass and energy balance, Order and rate of reactions, Batch reactors, Completely mixed flow reactors, Plug flow reactors.

Section 6: Air and Noise Pollution

Structure of the atmosphere; Natural and anthropogenic sources of pollution; Atmospheric sources, sinks, transport; Indoor air pollution; Effects on health and environment; Air pollution: gases and particulate matter; Air quality standards; Primary and secondary pollutants; Criteria pollutants, ambient and source standards, air quality indices, visibility.

Particulate pollutants: measurement and control methods; Control of particulate air pollutants using gravitational settling chambers, cyclone separators, wet collectors, fabric filters (Bag-house filter), electrostatic precipitators (ESP).

Gaseous Pollutants: Measurement and control methods; Control of gaseous contaminants: absorption, adsorption, condensation and combustion; Control of sulphur oxides, nitrogen oxides, carbon monoxide, and hydrocarbons; Vapour-liquid and vapour-solid equilibria; Diffusion, Fick's law and interfacial mass transfer.

Automotive emission controls, fuel quality, diesel particulate filters, catalytic convertors.

Air quality management: Point, line and area sources; Inventory; Influence of meteorology - wind rose diagrams, stability, mixing height, topography, dispersion modelling, monitoring.

Noise pollution: Sources; Health effects; Standards; Measurement and control methods.

Section 7: Solid and Hazardous Waste Management

Integrated solid waste management; Waste hierarchy; Rules and regulations for solid waste management in India.

Municipal solid waste management: Sources, generation, characteristics, collection and transportation, waste processing and disposal (including reuse options, biological methods, energy recovery processes and landfilling).

Hazardous waste management: Characteristics, generation, fate of materials in the environment, treatment and disposal.

Soil contamination and leaching of contaminants into groundwater.

Management of biomedical waste, plastic waste and E-waste: Sources, generation and characteristics; Waste management practices including storage, collection and transfer.

Section 8: Global and Regional Environmental Issues

Global effects of air pollution – Greenhouse gases, global warming, climate change, urban heat islands, acid rain, ozone hole.

Ecology and various ecosystems; Biodiversity; Factors influencing increase in population, energy consumption, and environmental degradation.

Section 9: Environmental Management and Sustainable Development

Environmental Management Systems; ISO14000 series; Environmental auditing: Environmental Impact Assessment; Life cycle assessment; Human health risk assessment

Environmental Law and Policy – Objectives; Polluter pays principle, Precautionary principle; The Water and Air Acts with amendments; The Environment (Protection) Act (EPA) 1986; National Green Tribunal Act, 2010; National Environment Policy; Principles of International Law and International treaties.

Energy and Environment: Energy sources – overview of resources and reserves; Renewable and non-renewable energy sources; Energy-Environment nexus.

Sustainable Development: Definition and concepts of sustainable development; Sustainable development goals; Hurdles to sustainability; Environment and economics

Sample GATE Paper (ES: Environmental Science and Engineering)

Q. 1 – Q. 25 carry one mark each. In multiple choice questions (MCQ), only one alternative is correct.

The relative error in the calculation of the volume of a sphere is nearly_____times the relative error in the measurement of the radius.

- (A) two (B) three (C) five (D) six

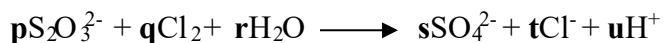
A river is 24 m wide. The depth Z in metres at a distance x m from one bank is given by the following table:

x	0	3	6	9	12	15	18	21	24
Z	0	1.2	2.1	2.7	3.6	4.5	4.2	2.4	0.9

The area of river cross section using Simpson's 1/3 rule is _____m² (rounding off to one decimal place).

- (A) 60.2 (B) 63.9 (C) 65.7 (D) 69.2

What are the values of q , r , s and u , respectively, in the following balance redox reaction:



- (A) 2, 5, 4, 10 (B) 4, 4, 2, 8 (C) 4, 5, 2, 10 (D) 2, 5, 2, 10

If $\text{PM}_{10} \text{ mass} > \text{PM}_{2.5} \text{ mass}$, number concentration of PM_{10} will always be: (A)

- > $\text{PM}_{2.5}$ (B) < $\text{PM}_{2.5}$
(C) $\geq \text{PM}_{2.5}$ (D) Depends on size distribution

Which of the following species have very long lifetime in the atmosphere? 1.

C_2H_4 , 2. N_2O , 3. NO_2 , 4. CH_4 ?

- (A) 1 and 4 (B) 2 and 3 (C) 2 and 4 (D) 3 and 4

The waste can be categorized as 'hazardous' if

- (A) it burns at temperatures more than 60°C
- (B) its pH is above 12.5
- (C) It reacts slowly with water
- (D) All of the above

A 2 m deep trickling filter with a diameter of 18 m is operated with a recirculation ratio of 1.5. The raw wastewater flow rate is 2.5 ML/d and the 5-day BOD of the raw sewage is 210 mg/L. Assuming that the primary tank BOD removal efficiency is 30%, compute organic load ($\text{kg/m}^3 \cdot \text{d}$) on the trickling filter.

- (A) 1.8
- (B) 0.72
- (C) 1.03
- (D) 1.1

If the average annual rainfall and evaporation over land masses and oceans of the earth are considered, it would be found that

- (A) over the land masses the annual evaporation is the same as the annual precipitation
- (B) over the oceans about 19% more rain falls than what is evaporated
- (C) about 9% more water evaporates from the oceans than what falls back on them as precipitation
- (D) over the oceans about 19% more water evaporates than what falls back on them as precipitation

There are four stages in the life of a lake: (i) Eutrophic, (ii) oligotrophic, (iii) mesotrophic and (iv) senescent. Which one is the correct order among the following:

- (A) (ii), (i), (iii) and (iv)
- (B) (iii), (iv), (ii) and (i)
- (C) (ii), (iii), (i) and (iv)
- (D) (ii), (iv), (iii) and (i)

If S_y = specific yield and S_r = specific retention, then

- (A) $S_y + S_r$ = void ratio
- (B) $S_y + S_r$ = porosity

(C) $S_y + S_r = 1.0$

(D) $S_y + S_r = \text{permeability}$

Q. 11 Sustainable development can be thought of in terms of three spheres i.e.

(A) environment, ecology and society

(B) environment, economy and society

(C) environment, economy and ecology

(D) environment, economy and equity

Q.12 If in a city, the maximum daily water draft is 25MLD, fire draft is 35 MLD and maximum hourly draft is 40 MLD, what is the coincident draft?

(A) 40 MLD

(B) 35 MLD

(C) 60 MLD

(D) 25 MLD

Q.13 Permanent hardness from water can be removed by the addition of

(A) Lime

(B) Soda ash

(C) Potassium permanganate

(D) Sodium bicarbonate

Q.14 According to Solid Waste Management Rules (2016) in India, all industrial units withinkm of RDF production plants shall replace at least 5% of their fuel by RDF.

(A) 50

(B) 100

(C) 150

(D) None of these

Q.15 Solar energy reaching the Earth is approximately:

(A) 2600 Wcm^{-2} (B) 1370 Wm^{-2} (C) 1730 Wm^{-2} (D) 7130 Wcm^{-2}

Q.16 In ISO 14000 series of standards, which one does not belong to 'Organization or process' standards:

(A) Environmental audit

- (B) Environmental performance evaluation
(C) Environmental aspects in product standards
(D) Environmental Management standards
- Q.17 The point of inflection on the recession limb of a hydrograph represents
(A) the cessation of rainfall
(B) the condition of maximum storage in the catchment
(C) the end of base flow
(D) peak runoff rate
- Q.18 Which of the following measures can be used for reducing road traffic noise?
(i) Use of noise barriers, (ii) Limiting vehicle speeds, (iii) Alteration of road surface
(A) i and ii (B) ii and iii (C) i and iii (D) all of the above
- Q.19 Which of the following are considered “criteria air pollutants”?
(A) CO₂, CO, NO₂, SO₂ (B) CO, NO_x, Pb, PM_{2.5}
(C) O₃, CO, NO₂, PM₁₀ (D) PM₁₀, SO_x, CO, NO_x
- Q.20 India’s energy needs are heavily dependent on coal-based thermal power plants, which are also one of the most polluting sources. Which of the following is the most dominant air pollutants that power plants emit?
(A) O₃ (B) SO₂ (C) CO (D) CO₂
- Q.21 A peptide bond is formed between two amino acids by the reaction of the _____ of one amino acid with the _____ of the other.
(A) R group/R group
(B) R group/carboxyl group

- (C) -H of the amino group/-OH of the carboxyl group
- (D) -NH₃ group/central carbon atom

Q. 22 Which of the following is true, with respect to a 3-way catalytic converter, which is used for controlling gaseous exhaust emissions in automobiles?

- (A) It oxidizes VOC and reduces CO
- (B) It oxidizes CO and reduces NO_x
- (C) It oxidizes NO_x and reduces SO₂
- (D) It oxidizes SO₂ and reduces VOC

Q.23 A 2 mL sewage sample having BOD₅ of 500 mg/L is diluted to 200 ml and incubated for 5 days at 20°C. If the dissolved oxygen (D.O.) content after 5 days is found to be 5 mg/L, the initial D.O. content of the diluted sample was_____mg/L. Your response should have no decimal digit.

Q.24 If the initial volume of the municipal solid waste is 18 m³ and after compaction it is reduced to 2 m³. The waste compaction ratio will be_____. Your response should have no decimal digit.

Q.25 For the same solids content, if the volume of sludge with moisture content of 97% is 30 m³, then the volume of sludge with moisture content of 94% will be_ m³. Your response should have no decimal digit.

Q. 26 – Q. 38 carry two marks each. These MCQs have only one correct choice.

Q.26 Particular solution to the differential equation $\frac{dy}{dx} + 2y = e^{-x}$, given $y = 1$ when $x = 0$, is _.

- (A) $y = e^{-x}$ (B) $y = e^x$ (C) $y = e^{2x}$ (D) $y = e^{-2x}$

Q.27 The value of $I = \int_1^2 \frac{dx}{(x^2 - 2x + 4)^{3/2}}$ is _____.

- (A) 1/16 (B) 1/6 (C) 1/8 (D) 1/4

Q.28 Assuming the unitless normalized values of turbidity and heavy metal concentration in river water are highly associated and may be represented by the random variables X and Y, respectively. The joint probability density function of these variables is given by

$$f(x, y) = \begin{cases} \frac{2}{3}(x+2y), & 0 \leq x \leq 1, 0 \leq y \leq 1 \\ 0 & \text{elsewhere} \end{cases}$$

The probability value, $P(X \leq 1/2, Y \leq 1/2)$ is _____.

- (A) 1/16 (B) 1/4 (C) 1/8 (D) 1/24

Q.29 The rainfall in three successive 8 hrs periods is 1.6, 5.4 and 4.1 cm. If the initial loss is 0.6 cm and, the surface runoff resulting from this storm is 4.7 cm, the ϕ index of infiltration for this storm is _____.

- (A) 0.30 cm/hr (B) 0.267 cm/hr (C) 0.20 cm/hr (D) 0.15 cm/hr

Q.30 Two reservoirs are connected by two pipes M and N of identical diameter and length, in parallel. If the friction factor of M is 4 times that of N, the ratio of the discharge in A to that of in B is _____.

- (A) 0.25 (B) 0.5 (C) 2.0 (D) 4.0

Q.31 A hydraulic jump takes place in a horizontal rectangular channel from a depth of 0.20 m to 2.40 m. The discharge in the channel in m^3/sec per metre width is _____.

- (A) 2.47 (B) 12.0 (C) 3.2 (D) 0.08

Q.32 The stream function in a two-dimensional flow field is given by $\psi = x^2 - y^2$. The magnitude of the velocity at point (1, 1) is_____.

- (A) 2 (B) $2\sqrt{2}$ (C) 4 (D) 8

Q.33 A 200 ml sample of water has an initial pH of 10. To titrate the sample to pH 4.5, 30 milliliters of 0.02 N H_2SO_4 is required. Suppose the 8.3 equivalence point is reached at 11 milliliters of acid. The total alkalinity of the water and its species (i.e., OH^- , CO_3^{2-} and HCO_3^-) in milligrams per liter as CaCO_3 will be as follows (in the same order):

- (A) 150, 5, 100, 45 (B) 150, 5, 45, 100 (C) 30, 1, 10, 19 (D) 30, 10, 1, 19

Q.34 The average per capita energy consumption of USA is about:

- (A) 5 times that of global average
(B) 50 times that of global average
(C) $(\text{Area of USA}/\text{Area of World})^{0.5}$ time that of the world
(D) 0.5 times that of India

Q.35 The latitudinal diversity gradient is defined as the decrease in the number of species from the equator to the poles. This can result from:

- (A) greater seasonal variation at the poles
(B) greater energy input at the poles
(C) greater land mass at the poles
(D) greater speciation rates at the poles

Q.36 Arrange the following in correct order for particulate matter (PM) measurements.



(A) 3, 1, 4, 2

(B) 3, 4, 1, 2

(C) 1, 3, 4, 2

(D) 1, 4, 3, 2

Q.37 Two noise sources produce 65 and 60 dB of noise for the same duration. What will be the resulting noise (in dB) that a person exposed to both the sources will experience?

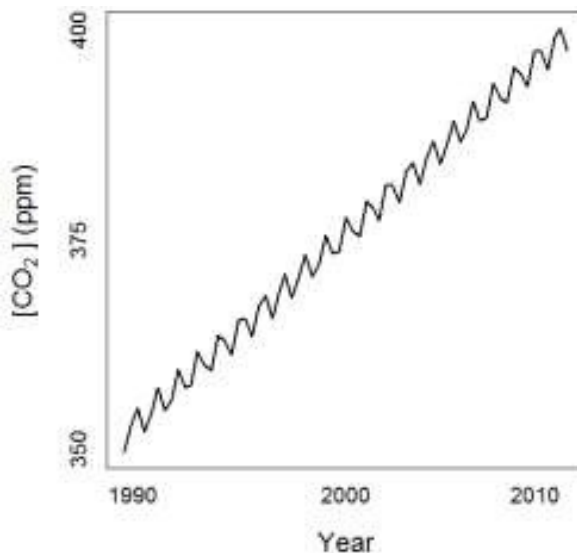
(A) 62.5

(B) 65.6

(C) 66.2

(D) 67.5

Q.38 A climate scientist notices a trend in atmospheric CO₂ concentrations (in ppm) at a research station. Although overall CO₂ is rising over decades, there are intra-annual fluctuations, as shown in the figure below.



These fluctuations can be attributed to

(A) burning of fossil fuels by automobiles and industry

(B) oscillations due to El Niño and La Niña events

- (C) rising sea levels due to melting of polar ice-caps
- (D) seasonal trends in photosynthesis and respiration

Q. 39 – Q. 50 carry 2 marks each. More than one alternatives are correct in these multiple select questions (MSQ).

Q.39 TDS in wastewater

- (A) May be caused by cations and anions
- (B) May be caused by undissociated organic substances
- (C) Is expected to show a good correlation with conductivity
- (D) Is expected to show a good correlation with alkalinity

Q.40 In Monod's Model for microbial growth relating the specific growth rate (μ) to substrate concentration (S) with $\mu_{\max}$ and K_s as model parameters:

- (A) The $\mu_{\max}$ value is an absolute maximum value of μ for the chosen microbe that is unaffected by the system conditions.
- (B) For any microbe, $\mu_{\max}$ is affected by the choice of substrate
- (C) The Monod model is not applicable for inhibitory substrates
- (D) Both μ and K_s can be expressed in mg/L

Q.41 The titration used for estimating hardness uses

- (A) Phenolphthalein as indicator
- (B) Eriochrome Black-T as indicator
- (C) Uses sodium thiosulphite as the titrant
- (D) Uses ethylenediaminetetraacetic acid as the titrant

Q.42 The combination that correctly matches an organelle in a microbe in Group-I to its function in Group-II

Group-I

(i) Mitochondria

Group-II

(a) Antibiotic resistance

- (ii) Chloroplast
- (iii) Cell Wall
- (iv) Plasmids
- (b) Shape and rigidity
- (c) Respiration
- (d) Photosynthesis

(A) i and b; (B) ii and a; (C) iii and b; (D) iv and a

Q.43 Identify the **incorrect choices** pertaining to the polysaccharides, starch and cellulose

- (A) The component monomers in starch and cellulose are enantiomers
- (B) The component monomers in starch and cellulose are anomers
- (C) The component monomers in starch and cellulose are stereoisomers
- (D) In both starch and cellulose the monomers are joined by identical bonds

Q.44 Identify the **correct choices** pertaining to the process of glycolysis in microorganisms

- (A) Is identical in all microorganisms
- (B) The first two steps are identical in all microorganisms but the third step differs
- (C) Involves substrate level phosphorylation
- (D) Involves a-ketoglutarate as an intermediate

Q.45 Which of the following traits are **not necessary** for a good indicator organism

- (A) It should be a Gram negative rod-shaped bacteria
- (B) It should be non-pathogenic
- (C) It should have the ability to multiply in the environment
- (D) It must possess greater resistance to disinfectants compared to pathogenic microbes

Q.46 With regard to segregation and treatment of municipal solid waste, which of the statements are correct?

- (A) Stoners are used for the separation of heavy grit from lighter material
- (B) Composting of biodegradable waste is a produces biogas and manure
- (C) Aluminum separation from solid wastes can be accomplished by eddy current separators

(D) Trommels are used to shred the waste

Q.47 The plastic waste can be used for following purposes:

(A) Road construction

(B) Generation of syn gas

(C) Manure production

(D) Biogas production

Q.48 Identify the tasks that are included in an Impact assessment.

(A) a detailed assessment of the planned project and selected alternatives compared to the baseline conditions

(B) Qualitative descriptions measuring high, medium and low impacts

(C) Quantitative descriptions such as indicating the cubic metres of water withdrawn, sewage produced, and pollutants released

(D) All the data collection, analyses, and developed plans summarized together in a well-structured and concise document

Q.49 Identify the choices that pertain to principles inherent in international law:

(A) The polluter pays principle

(B) Principle of non-discrimination

(C) Precautionary principle

(D) Principle of intergenerational equity

Q.50 Identify the correct choice pertaining to DNA and RNA nucleotides

(A) The sugar is identical in both DNA and RNA nucleotides but the nitrogenous base differs

(B) In both DNA and RNA nucleotides, the sugar is a pentose sugar that is structurally different at two positions

(C) The nitrogenous base in both DNA and RNA nucleotides contain one or two heterocyclic rings

(D) The pyrimidine base uracil is present only in RNA

Q. 51 – Q. 55 carry 2 marks each. Fill in the blanks.

- Q.51 A toxicological analysis of particulate matter (PM) requires a minimum of 0.5 mg mass. You decide to use a low volume air sampler ($Q = 5 \text{ L/min}$). If a household with a smoker has $90 \mu\text{g/m}^3$ average indoor PM levels, the sample would have to be collected for _____ hours. Your response should have one digit after decimal point.
- Q.52 The capacity of a septic tank is to be determined using the following information: No. of people = 100; sewage generation per capita per day = 120 litres; desludging period = 1 year, detention time = 24 h, rate of sludge deposit in tank = 30 litres/capita/year, length: width ratio = 4:1. The capacity of tank will be _____ m^3 . Your response should have no decimal digit.
- Q.53 A sanitary landfill has the following specifications: Design life of the site = 40 years; MSW generation rate = 20 N/person/day; municipal solid waste (MSW) compacted unit weight = 8 kN/m^3 ; Average fill depth = 10 m; Population = 50,000; MSW to cover ratio = 4:1. The area required for sanitary landfill will be _____ hectares. Your response should have no decimal digit.
- Q.54 Suppose 30 out of 500 rats exposed to a potential carcinogen develop tumors. A control group of 300 rats not exposed to the carcinogen develops only 10 tumors. Based on these data, the Attributable (additional) Risk is _____. Your response should have three decimal digits.
- Q.55 With a chlorine dose of 0.1 mg/L 80% of the bacteria are killed in 2 min. If Chick's law, is valid the rate of kill of bacteria by chlorination should follow first-order kinetics and the contact time required to kill 99% of the bacteria with this dose, rounded off to the nearest integer will be _____ min.

Answer Key: ES – Environmental Science and Engineering

Q. No.	Type	Section	Key	Marks
1	MCQ	ES	B	1
2	MCQ	ES	B	1
3	MCQ	ES	C	1
4	MCQ	ES	D	1
5	MCQ	ES	C	1
6	MCQ	ES	B	1
7	MCQ	ES	B	1
8	MCQ	ES	C	1
9	MCQ	ES	C	1
10	MCQ	ES	B	1
11	MCQ	ES	B	1
12	MCQ	ES	C	1
13	MCQ	ES	B	1
14	MCQ	ES	B	1
15	MCQ	ES	B	1
16	MCQ	ES	C	1
17	MCQ	ES	B	1
18	MCQ	ES	D	1
19	MCQ	ES	C	1
20	MCQ	ES	B	1
21	MCQ	ES	C	1
22	MCQ	ES	B	1
23	NAT	ES	10 to 10	1
24	NAT	ES	9 to 9	1
25	NAT	ES	15 to 15	1
26	MCQ	ES	A	2
27	MCQ	ES	B	2
28	MCQ	ES	C	2
29	MCQ	ES	A	2
30	MCQ	ES	B	2
31	MCQ	ES	A	2
32	MCQ	ES	B	2
33	MCQ	ES	A	2
34	MCQ	ES	A	2
35	MCQ	ES	A	2
36	MCQ	ES	B	2
37	MCQ	ES	C	2
38	MCQ	ES	D	2
39	MSQ	ES	A, B	2
40	MSQ	ES	B, C	2
41	MSQ	ES	B, D	2
42	MSQ	ES	C, D	2

Q. No.	Type	Section	Key	Marks
43	MSQ	ES	A, D	2
44	MSQ	ES	B, C	2
45	MSQ	ES	A, C	2
46	MSQ	ES	A, C	2
47	MSQ	ES	A, B	2
48	MSQ	ES	A, B, C	2
49	MSQ	ES	A, B, C, D	2
50	MSQ	ES	B, D	2
51	NAT	ES	18.5 to 18.6	2
52	NAT	ES	15 to 15	2
53	NAT	ES	23 to 23	2
54	NAT	ES	0.026 to 0.027	2
55	NAT	ES	6 to 6	2