

General Instructions

- (i) This question paper contains 65 questions. All questions are compulsory.
- (ii) It comprises 35 single-correct multiple-choice questions, 9 multiple-correct questions and 21 numerical / integer-type questions.
- (iii) Attempt every question; detailed solutions are provided in the companion solutions booklet.
- (iv) For multiple-correct questions, all correct options must be selected to earn full marks.
- (v) For numerical questions, report the answer rounded exactly as asked.

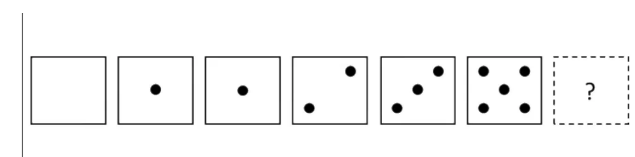
1. Suresh said, "I did it yesterday."

Which one of the following options is the correct form of this sentence in indirect speech?

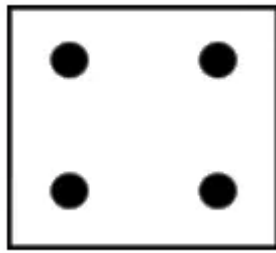
- (A) Suresh said that I did it yesterday.
- (B) Suresh says I did it yesterday.
- (C) Suresh says that he did it the day before.
- (D) Suresh said that he had done it the day before.

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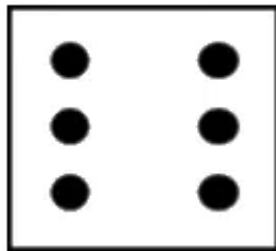
2. To continue the sequence of tiles shown, the tile indicated by the question mark should be:



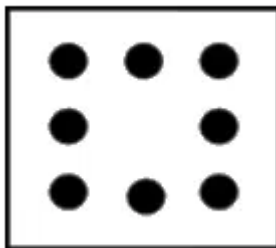
(A)



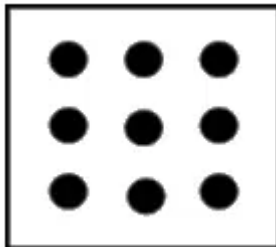
(B)



(C)

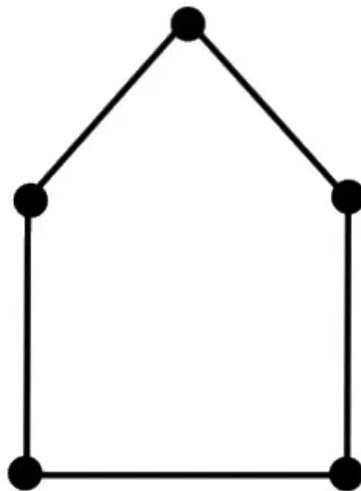


(D)



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3. Consider an art gallery whose walkways are shown as lines in the diagram. A black dot represents a junction of two walkways. A guard may be placed at a junction to watch over the walkways that join at that junction. The minimum number of guards needed to watch all the walkways is _____.



- (A) 2
- (B) 3
- (C) 4
- (D) 5

...

4. The 2nd of June is a Thursday in a certain year. Which day of the week is the 3rd of July in that year?

- (A) Thursday
- (B) Friday
- (C) Saturday
- (D) Sunday

...

5. A coin with heads facing up is shown as (H) and a coin with tails facing up is shown as (T).

Six coins are placed in the Starting Arrangement, as shown in the figure below. A “step” is defined as interchanging a pair of adjacent coins without flipping them. The minimum number of steps needed to go from the Starting Arrangement to the Final Arrangement, as shown in the figure, is _____.



- (A) 3
- (B) 6
- (C) 9
- (D) 12

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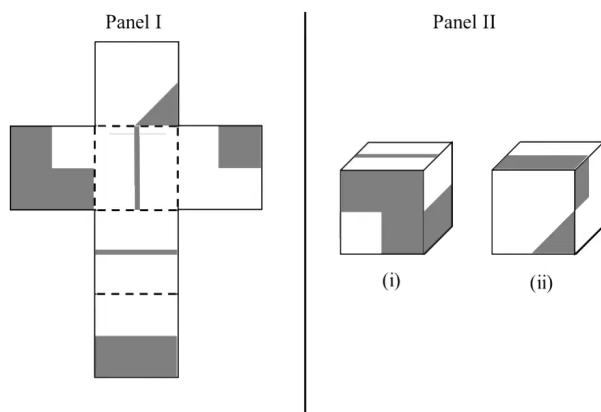
6. Exacerbate : Mitigate :: _____

Choose the option with the correct pair of words to fill the blank.

- (A) Aggravate : Alleviate
- (B) Alleviate : Precipitate
- (C) Aggravate : Precipitate
- (D) Emancipate : Exonerate

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7. A paper shown in Panel I is folded along the dashed lines (---) to construct a cube. The shaded regions shown in Panel I appear on the outer surface of the cube. Referring to cubes shown in Panel II, which one of the options is correct?



- (A) Only (i) can correspond to the unfolded cube in Panel I.
 (B) Only (ii) can correspond to the unfolded cube in Panel I.
 (C) Both (i) and (ii) can correspond to the unfolded cube in Panel I.
 (D) Neither (i) nor (ii) can correspond to the unfolded cube in Panel I.

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8. In a population, patients who have high cholesterol also have high blood-pressure (BP). Some patients with high BP also have diabetes. There are no patients who have both high cholesterol and diabetes. Furthermore,

1. the total number of patients with at least one of these conditions is 75,
 2. the number of patients with high cholesterol is 10,
 3. the number of patients with high BP is 45, and
 4. the number of patients with only high BP and no other conditions is 20.
- Then the number of patients who have both diabetes and high BP is

- (A) 0
- (B) 15
- (C) 20
- (D) 10

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9. Four people P, Q, R, and S, of different ages, make the following observations.

P - I am younger than S.

Q - I am neither the youngest nor the oldest.

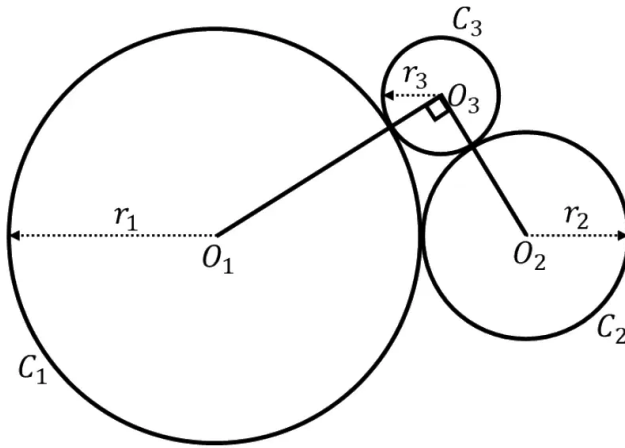
R - P is older than me.

Based on these observations, the youngest person is _____.

- (A) P
- (B) Q
- (C) R
- (D) S

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10. Circles C_1 , C_2 , and C_3 , with centers O_1 , O_2 , and O_3 , and radii r_1 , r_2 , and r_3 , respectively, touch each other as shown in the following figure. Given $r_1 = 2$ cm, $r_2 = 1$ cm and the angle $\angle O_1O_3O_2$ is 90 degrees, $r_3 =$ _____ cm.



- (A) $\frac{1}{2}(-3 + \sqrt{17})$
- (B) $\frac{1}{2}(3 + \sqrt{17})$
- (C) $\frac{1}{2}(-2 + \sqrt{17})$
- (D) $\frac{1}{2}(-3 + 2\sqrt{17})$

...

11. If $2X + \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} = \begin{bmatrix} 3 & 8 \\ 7 & 2 \end{bmatrix}$, then X is _____.

- (A) $\begin{bmatrix} 2 & 5 \\ 5 & 3 \end{bmatrix}$
- (B) $\begin{bmatrix} -1 & 3 \\ 2 & -1 \end{bmatrix}$
- (C) $\begin{bmatrix} 1 & 3 \\ 2 & -1 \end{bmatrix}$
- (D) $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

...

12. The correct integral of $\int \frac{\sin x}{\sqrt{1 + \cos x}} dx$ (assuming integral constant as c) is _____.

- (A) $-2\sqrt{2} \sin \frac{x}{2} + c$
- (B) $-2\sqrt{2} \cos \frac{x}{2} + c$
- (C) $-\frac{1}{\sqrt{2}} \cos \frac{x}{2} + c$
- (D) $-\frac{1}{\sqrt{2}} \sin \frac{x}{2} + c$

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13. Given $f(x) = 3x^4 + 4x^3 - 12x^2 + 6$, the minimum value of $f(x)$ is _____.

- (A) -6
- (B) -36
- (C) -26
- (D) -46

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14. A box contains 26 cards with all English alphabets from A to Z. The probability of randomly choosing the card with either 'E' or 'S' from this box is _____.

- (A) $2/26$
- (B) $1/26$
- (C) $3/26$
- (D) $4/26$

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15. Which ONE of the following options is the CORRECT formula for Chi-Square (χ^2) test?

Given, $O_1, O_2, \dots, O_n$ are the observed values, $E_1, E_2, \dots, E_n$ are the corresponding expected values, $\bar{O}$ is the mean of observed values, n is the number of observations, μ is the mean of $E_i, i = 1, \dots, n$, σ_o is the standard deviation of observed values, and σ_E is the standard deviation of expected values $E_i, i = 1, \dots, n$.

(A) $\chi^2 = \sum_{i=1}^n \frac{(O_i - E_i)^2}{E_i}$

(B) $\chi^2 = \sqrt{\frac{\sum_{i=1}^n (O_i - \bar{O})^2}{n - 1}}$

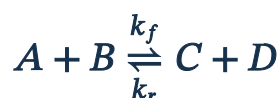
(C) $\chi^2 = \frac{\bar{O} - \mu}{\sigma_o \sqrt{n}}$

(D) $\chi^2 = \frac{(\sigma_o)^2}{(\sigma_E)^2}$

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16. In the reversible reaction shown below, k_f is the forward reaction rate constant and k_r is the reverse reaction rate constant.

The CORRECT expression representing the reaction equilibrium constant is _____.



(A) $k_f + k_r$

(B) $k_f \times k_r$

(C) $\frac{k_f}{k_r}$

(D) $\frac{k_r}{k_f}$

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17. The major class of enzymes catalyzing the cleavage of $C - C$, $C - O$, $C - N$, or other bonds by elimination, leaving double bonds or rings, or addition of groups to double bonds in any biochemical reactions is _____.

- (A) lyases
- (B) transferases
- (C) oxidoreductases
- (D) hydrolases

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18. Malaria is caused by pathogenic _____.

- (A) bacteria
- (B) fungi
- (C) protozoa
- (D) viruses

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19. Consider the following statements regarding the pressure measured at a point in a fluid.

S1: Absolute pressure is gauge pressure plus atmospheric pressure.

S2: Gauge pressure is measured by considering absolute zero pressure as datum.

S3: Absolute pressure is measured by considering atmospheric pressure as datum.

S4: Vacuum pressure is negative pressure obtained by subtracting absolute pressure from atmospheric pressure.

Which ONE of the following options lists all the TRUE statements?

- (A) S1 and S2
- (B) S2 and S3
- (C) S1 and S4
- (D) S1, S2, and S4

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20. Which ONE of the following options CORRECTLY matches the processes associated with the growth condition given in the table?

Process	Growth Condition
(P) Activated sludge process	(i) Anaerobic suspended growth
(Q) Anaerobic filter	(ii) Anaerobic attached growth
(R) Trickling filter	(iii) Aerobic suspended growth
(S) Anaerobic digestion	(iv) Aerobic attached growth

- (A) (P) - (ii); (Q) - (iii); (R) - (iv); (S) - (i)
- (B) (P) - (iii); (Q) - (ii); (R) - (iv); (S) - (i)
- (C) (P) - (iii); (Q) - (i); (R) - (iv); (S) - (ii)
- (D) (P) - (iv); (Q) - (iii); (R) - (ii); (S) - (i)

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21. In the design of air pollution control devices, size of the particles that are removed with 50% efficiency is termed as _____.

- (A) mean size
- (B) mode size
- (C) cut size
- (D) median size

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22. The general atmospheric composition of gases in the decreasing order is _____.

- (A) $\text{N}_2 > \text{O}_2 > \text{CO} > \text{CO}_2 > \text{NH}_3$
- (B) $\text{N}_2 > \text{O}_2 > \text{CO}_2 > \text{CO} > \text{NH}_3$
- (C) $\text{N}_2 > \text{CO}_2 > \text{O}_2 > \text{NH}_3 > \text{CO}$
- (D) $\text{N}_2 > \text{CO}_2 > \text{NH}_3 > \text{CO} > \text{O}_2$

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23. Which ONE of the following options is NOT a parameter as a part of proximate analysis of municipal solid waste?

- (A) Volatile matter
- (B) Ash content
- (C) Carbon to nitrogen ratio
- (D) Moisture content

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24. A species whose impact on an ecosystem is disproportionately large in comparison to its population is called _____ species.

- (A) dominant
- (B) keystone
- (C) apex predator
- (D) endemic

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25. Which ONE of the following principles is directly related to environmental compensation?

- (A) Intergenerational equity principle
- (B) Precautionary principle
- (C) Subsidiarity principle
- (D) Polluter-pay principle

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26. As per the United Nations General Assembly resolution adopted in 2015 "Transforming Our World: The 2030 Agenda for Sustainable Development", the number of sustainable development goals (SDGs) is _____.

- (A) 4
- (B) 15
- (C) 17
- (D) 11

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27. Which ONE of the following options CORRECTLY matches the ISO series with their usages in environmental management system (EMS) given in the table?

ISO Series	Environmental Management System
(P) ISO 14001	(i) Environmental labeling
(Q) ISO 14020	(ii) Evaluation of environmental management system
(R) ISO 14040	(iii) Addressing environmental aspects of products
(S) ISO 14060	(iv) Life cycle assessment procedure

- (A) (P) - (i); (Q) - (ii); (R) - (iii); (S) - (iv)
- (B) (P) - (ii); (Q) - (i); (R) - (iv); (S) - (iii)
- (C) (P) - (iii); (Q) - (iv); (R) - (i); (S) - (ii)
- (D) (P) - (iv); (Q) - (iii); (R) - (ii); (S) - (i)

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28. Which of the following chemical reactions is/are related to smog formation in the troposphere?

- (A) $CFCl_3 + h\nu \rightarrow CFCl_2 + Cl\cdot$
- (B) $CH_3O_2 + NO + O_2 \rightarrow HCHO + HO_2 + NO_2$
- (C) $NO_2 + O_2 + h\nu \xrightarrow{M} O_3 + NO$
- (D) $CH_4 + 8O_2 \rightarrow CO + H_2O + 2OH\cdot + 4O_3$

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29. Which of the following processes is/are primarily used to remove the organic matter in sludge?

- (A) Digestion
- (B) Incineration
- (C) Magnetic separation
- (D) Wet-oxidation

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30. Which of the following options is/are CORRECTLY listing the species included in Total Kjeldahl Nitrogen (TKN) estimation of an aqueous sample?

- (A) Ammoniacal - N
- (B) Nitrite - N
- (C) Nitrate - N
- (D) Organic - N

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31. Which of the following statements is/are CORRECT in the context of hazardous waste management and its risk assessment?

- (A) Risk is estimated based on the probability of an action occurring multiplied by the severity of damage.
- (B) High octanol water constant (K_{OW}) is indicative of lower accumulation of an organic chemical in body tissue.
- (C) Pump and treat is an example of contaminated groundwater remediation.
- (D) Biological treatment processes are never applied for hazardous waste management.

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32. Which of the following statements is/are TRUE about global warming?

- (A) Interception of incoming solar radiation by greenhouse gases in earth's atmosphere is responsible for global warming.
- (B) Interception of outgoing longwave radiation by greenhouse gases in earth's atmosphere is responsible for global warming.
- (C) Global warming can cause sea level rise.
- (D) Carbon dioxide is one of the major greenhouse gases in earth's atmosphere responsible for global warming.

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33. Which of the following options is/are directly associated with the steps involved in carrying out life cycle assessment (LCA)?

- (A) Determination of functional unit
- (B) Defining goal and scope
- (C) Defining technology readiness level
- (D) Listing out inventory of inputs and outputs

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34. A 6-hour rainfall of 6 cm at a station was found to have a return period of 40 years. The probability that a 6-hour rainfall of this or larger magnitude will occur at least once in 20 successive years at that station is _____ (rounded off to three decimal places).

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35. Water is flowing at the rate of $15 \text{ m}^3/\text{s}$ through a rectangular channel of 5 m width. If the acceleration due to gravity (g) is 9.81 m/s^2 , the critical velocity for the flow is _____ m/s (rounded off to three decimal places).

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36. A first-order ordinary differential equation is given as follows:

$$\frac{dy}{dx} + x^2y = 0$$

Which ONE of the following options CORRECTLY represents the characteristics of this equation?

- (A) Linear, homogeneous, and exact
- (B) Nonlinear, nonhomogeneous, and exact
- (C) Linear, homogeneous, and non-exact
- (D) Nonlinear, nonhomogeneous, and non-exact

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37. Consider the matrix $A = \begin{bmatrix} 2 & 2 & 3 \\ 2 & 5 & 6 \\ 3 & 4 & 10 \end{bmatrix}$. Which ONE of the following

options CORRECTLY lists the eigenvalues of A ?

(A) $1; 8 - \sqrt{37}; -8 + \sqrt{37}$

(B) $2; 8 - \sqrt{37}; -8 + \sqrt{37}$

(C) $1; 8 + \sqrt{37}; 8 - \sqrt{37}$

(D) $2; 8 + \sqrt{37}; 8 + \sqrt{37}$

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38. Which ONE of the following options is CORRECT with respect to sequential breakdown of deoxyribonucleic acid (DNA) into lower-molecular weight compounds?

(A) Deoxyribonucleic acid $\rightarrow$ 2-deoxyribose $\rightarrow$ Nucleosides $\rightarrow$ Nucleotides

(B) Deoxyribonucleic acid $\rightarrow$ 2-deoxyribose $\rightarrow$ Nucleotides $\rightarrow$ Nucleosides

(C) Deoxyribonucleic acid $\rightarrow$ Nucleotides $\rightarrow$ Nucleosides $\rightarrow$ 2-deoxyribose

(D) Deoxyribonucleic acid $\rightarrow$ Nucleosides $\rightarrow$ Nucleotides $\rightarrow$ 2-deoxyribose

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39. Which ONE of the following options CORRECTLY matches the Criteria Air Pollutants with measurement methods used in Continuous Ambient Air Quality Monitoring Stations (CAAQMS) operated by Central Pollution Control Board (CPCB) given in the table?

Criteria Air Pollutants	Measurement Methods
(P) Sulphur Dioxide (SO ₂ , in µg/m ³)	(i) Chemiluminescence
(Q) Nitrogen Dioxide (NO ₂ , in µg/m ³)	(ii) Non Dispersive Infra Red (NDIR) spectroscopy
(R) Particulate Matter (PM _{2.5} , in µg/m ³)	(iii) Ultraviolet fluorescence
(S) Carbon Monoxide (CO, in mg/m ³)	(iv) Beta attenuation

- (A) (P) - (i); (Q) - (ii); (R) - (iii); (S) - (iv)
- (B) (P) - (iv); (Q) - (iii); (R) - (ii); (S) - (i)
- (C) (P) - (iii); (Q) - (i); (R) - (iv); (S) - (ii)
- (D) (P) - (ii); (Q) - (iii); (R) - (i); (S) - (iv)

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40. Which ONE of the following options CORRECTLY matches the atmospheric stability conditions with plume conditions/ behaviours given in the table?

Atmospheric Stability Conditions	Plume Conditions/Behaviours
(P) Strong instability	(i) Fanning plume
(Q) Neutral stability	(ii) Fumigation
(R) Surface inversion	(iii) Coning plume
(S) Aloft inversion	(iv) Looping plume

- (A) (P) - (i); (Q) - (ii); (R) - (iii); (S) - (iv)
- (B) (P) - (iv); (Q) - (iii); (R) - (i); (S) - (ii)
- (C) (P) - (iii); (Q) - (iv); (R) - (ii); (S) - (i)
- (D) (P) - (ii); (Q) - (i); (R) - (iv); (S) - (iii)

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41.

The analysis of a water sample is shown in the table. The hardness of the water sample is _____ mg/L as CaCO_3 .

Atomic weight (g/mol): Ca = 40; Mg = 24; Na = 23; Cl = 35.5; S = 32; O = 16; N = 14

Species Concentration (mg/L)

Na^+	30
Ca^{2+}	10
Mg^{2+}	15
Cl^-	30
SO_4^{2-}	60
NO_3^-	5

- (A) 87.5
- (B) 62.5
- (C) 25.5
- (D) 47.5

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42. Which ONE of the following statements is CORRECT regarding the eigenvalues of a real symmetric matrix?

- (A) The eigenvalues are always complex
- (B) The eigenvalues are always real
- (C) The eigenvalues are always negative
- (D) The eigenvalues are always equal to each other

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43. In the context of biological wastewater treatment, which of the following pairs CORRECTLY match the electron donor/acceptor with the corresponding biological process?

- (A) Nitrification: Ammonium as electron donor, oxygen as electron acceptor
- (B) Denitrification: Organic carbon as electron donor, nitrate as electron acceptor
- (C) Sulfate reduction: Oxygen as electron donor, sulfate as electron acceptor
- (D) Methanogenesis: Hydrogen as electron donor, carbon dioxide as electron acceptor

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44. Which of the following statements is/are CORRECT regarding reverse osmosis (RO) as a water/wastewater treatment process?

- (A) RO removes dissolved gases like CO₂ more effectively than dissolved salts
- (B) RO can remove monovalent ions such as sodium and chloride from water
- (C) RO membrane rejects dissolved solutes while allowing water to pass through under applied pressure exceeding osmotic pressure
- (D) RO does not require any external pressure to drive the separation process

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45. In the context of coagulation-flocculation used in water treatment, the compression of the electrical double layer around a colloidal particle, brought about by the addition of an electrolyte, primarily reduces the thickness of which ONE of the following layers?

- (A) Bulk solution layer
- (B) Shear plane only
- (C) Stern layer and diffuse layer
- (D) Van der Waals layer

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46. Which of the following are valid assumptions of the Gaussian plume dispersion model used for estimating ground-level pollutant concentrations from a point source?

- (A) The pollutant is conservative, i.e., it does not undergo any chemical reaction, decay, or deposition during transport
- (B) Wind speed and direction are constant (steady-state) over the travel time being modeled
- (C) The terrain is highly irregular with complex topographic features
- (D) Emission rate from the source varies significantly with time during the modeled period

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47. Sound pressure levels were measured at a location over four consecutive 15-minute intervals as 65 dB, 70 dB, 68 dB, and 72 dB. The equivalent continuous sound level (L_{eq}) over the total one-hour period is _____ dB (rounded off to two decimal places).

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48. The BOD_5 values (in mg/L) measured for five samples of wastewater are 20, 35, 40, 15, and 30. The standard deviation of these BOD_5 values is _____ mg/L (rounded off to one decimal place).

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49.

The mixing ratio of CO₂ at a pressure of 1 atm and at 300 K is reported as 340 ppmv.

Considering ideal gas conditions, the equivalent concentration of CO₂ in air is _____ mg/m³ (rounded off to two decimal places).

The molecular weight of CO₂ = 44 g/mol

Universal gas constant = 8.314 J/mol-K

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50.

Reaction A → B follows first-order elementary kinetics and the reaction rate constant for A is 0.01 per min.

The time taken to reduce the concentration of A from 100 M to 10 M in a batch reactor is _____ min (rounded off to one decimal place).

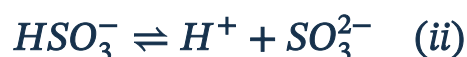
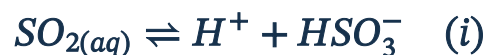
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51.

The following two reactions describe the chemistry of S(IV) in an aquatic system.

Under ideal conditions, the equilibrium constants for reactions (i) and (ii) are $1.3 \times 10^{-2} M$ (K_{S1}) and $6.6 \times 10^{-8} M$ (K_{S2}), respectively.

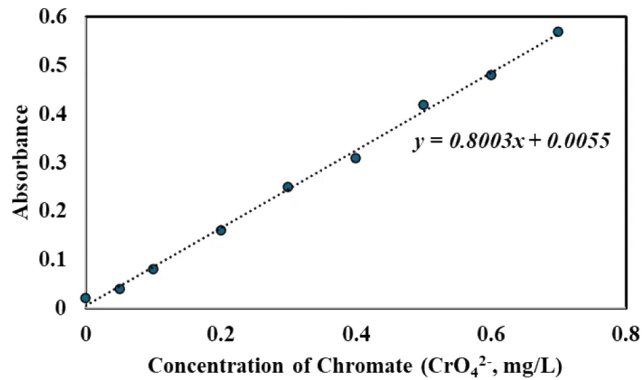
If the pH of the system is 4.0 and the equilibrium concentration of SO_{2(aq)} is 1.0 M, the equilibrium concentration of SO₃²⁻ is _____ mM (rounded off to one decimal place).



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52.

The calibration graph between absorbance and the concentration of chromate (CrO_4^{2-}) in a water sample is shown in the figure.



The calibration line shown in the figure has the equation $y = 0.8003x + 0.0055$, where y is the absorbance and x is the concentration of chromate (CrO_4^{2-} , mg/L).

For an absorbance of 0.35 in a water sample, the estimated Cr(VI) concentration is _____ mg/L (rounded off to two decimal places).

Use the atomic weight (g/mol) of Cr and O as 52 and 16, respectively.

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53.

In a batch culture experiment, 2 cells of a microorganism were added to a growth medium. During the experiment, a lag phase of 1 hour was first experienced by the added cells, in which no cell multiplication occurred. Afterwards, cells started multiplying exponentially with a doubling time of 1 hour.

After total 8 hours of experiment, the number of cells present in the growth medium was _____ (answer in integer).

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54.

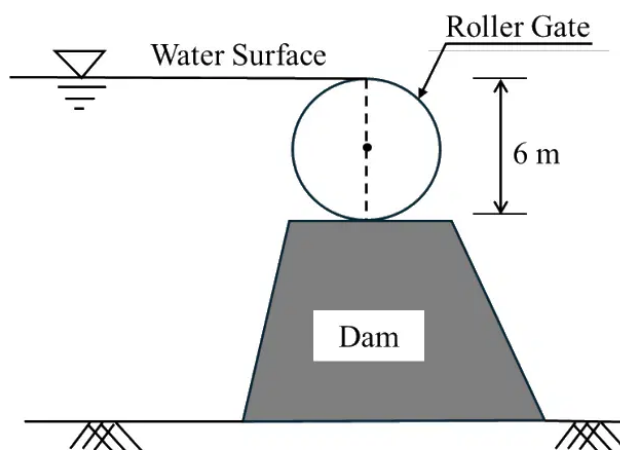
A thermal process, at a specific temperature, results in 2-log_{10} removal of non-thermotolerant pathogenic microorganisms from a water sample in 20 min.

The time needed to achieve 99.999% removal of these microorganisms under similar condition is _____ min (answer in integer).

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55.

A cylindrical roller gate of diameter 6.0 m and length 10.0 m is placed on a dam to store water behind it, as shown in figure.



Dimensions are NOT TO SCALE

The magnitude of the resultant force due to water acting on that gate when the water is about to spill is _____ $\times 10^6$ N (rounded off to two decimal places).

Consider acceleration due to gravity (g) = 9.81 m/s^2 ;

density of water (ρ) = 1000 kg/m^3 ; and $\pi = 3.14$.

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56.

The mass curve of a rainfall event of 100 min duration over a catchment is given in the table.

Time from start of rainfall (min)	0	20	40	60	80	100
Cumulative rainfall (cm)	0	0.5	1.2	2.6	3.3	3.5

If the initial loss is 0.6 cm and ϕ -index is 0.6 cm/hour, the total surface runoff from the catchment is _____ cm (rounded off to one decimal place).

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57. A well penetrates an unconfined aquifer. The water level (i.e., head) in the well prior to pumping is 25 m. After a long period of pumping at a constant rate of $0.05 \text{ m}^3/\text{s}$, the drawdowns at distances of 50 m and 150 m from the well are observed to be 3 m and 1.2 m, respectively.

The hydraulic conductivity of the unconfined aquifer is _____ $\times 10^{-4} \text{ m/s}$ (rounded off to two decimal places).

Consider $\pi = 3.14$.

• • •

58. A sewage treatment plant employing activated sludge process is operated under the following conditions:

Wastewater flow rate into the aeration tank = $0.150 \text{ m}^3/\text{s}$

Soluble BOD_5 in the influent = 84 mg/L

Soluble BOD_5 in the effluent = 11 mg/L

Mean cell residence time = 5 days

Total yield co-efficient = $0.5 \text{ kg of MLVSS/kg BOD}_5 \text{ removed}$

Decay rate of microorganism = $0.050/\text{day}$

The net waste activated sludge produced in the plant is _____ kg of VSS/day (rounded off to two decimal places).

• • •

59. A continuous flow stirred tank reactor (CSTR) operates under a steady-state condition with a flow rate of 300 L per hour. The influent concentration of a substrate entering the reactor is 150 mg/L .

To give a treatment efficiency of 76% for the substrate that decays according to half-order kinetics with a rate constant of $0.05 (\text{mg/L})^{1/2}$ per hour, the required volume of the reactor is _____ m^3 (answer in integer).

• • •

60. In a stack emission measurement at an industry, the stack cross-sectional area at 30 m height was divided into four equal sectors. The measured velocities and SO₂ concentrations through these sectors at this height are given in the table.

The mean SO₂ concentration from the stack is _____ mg/m³ (rounded off to two decimal places).

Sector Number	Velocity (m/s)	SO ₂ Concentration (mg/m ³)
1	15	1000
2	17	1150
3	19	1250
4	21	1275

• • •

61. An anaerobic digestion system is operated for methane gas generation from organic fraction of municipal solid waste (OFMSW). The moisture content and volatile solids (VS) content of OFMSW are 20% and 90%, respectively. The biodegradable volatile solids (BVS) in the VS is 70%, and the BVS conversion efficiency to methane gas is 85%.

If the methane gas generation in the system is 12 m³ per kg of BVS converted, the total volume of gas produced from one kilogram of OFMSW is _____ m³ (rounded off to two decimal places).

• • •

62. The characteristics of two types of solid waste are given in the table.

Type of solid waste	Moisture content (%)	Nitrogen content (%)	Carbon to Nitrogen (C/N) ratio
Leaves	50	0.7	50
Sludge	75	5.6	6.3

The quantity of sludge to be added to leaves to achieve a C/N ratio of 25 (on dry basis) for the mixed waste is _____ kg of sludge/kg of leaves (rounded off to three decimal places).

• • •

63. The concentration of chemical A in ambient air is $50 \mu\text{g}/\text{m}^3$ and the toxicological index limit for a threshold health effect for this chemical is 5 mg.

If the average breathing rate is 4 L/min, the minimum time of exposure that can lead to any health effect is _____ days (rounded off to one decimal place).

• • •

64. The area in the first quadrant bounded by the function $y = (8 - x)$ and the coordinate axes is _____ square units (answer in integer).

• • •

65. An agricultural land can support energy crops yield to produce 7000 L of bioethanol per hectare and energy content of bioethanol is 21 MJ/L. This bioethanol displaces fossil-based petrol.

The CO_2 offset potential of land used for growing energy crops as a bioethanol feedstock is _____ $\times 10^6$ g of CO_2 /hectare (rounded off to one decimal place).

Consider CO_2 footprints of 10 g and 80 g of CO_2 per MJ for bioethanol and petrol, respectively.