GATE 2024 ES

EE25BTECH11006 - ADUDOTLA SRIVIDYA

Q.1 – Q.5 Carry ONE mark each

Q1. If '→' denotes increasing order of intensity, then the meaning of the words sick → infirm → moribund is analogous to silly → _____ → daft Which one of the given options is appropriate to fill the blank?

a) frown b) fawn c) vein d) vain

Q2. The 15 parts of the given figure are to be painted such that no two adjacent parts with shared boundaries (excluding corners) have the same color. The minimum number of colors required is

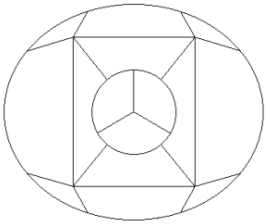


Fig. Q2..1: First figure

a) 4 b) 3 c) 5 d) 6

Q3. How many 4-digit positive integers divisible by 3 can be formed using only the digits $\{1, 3, 4, 6, 7\}$, such that no digit appears more than once in a number?

a) 24 b) 48 c) 72 d) 12

Q4. The sum of the following infinite series is

$$2 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{8} + \frac{1}{9} + \frac{1}{16} + \frac{1}{27} + \cdots$$

a) 11/3 b) 7/2 c) 13/4 d) 9/2

Q5. In an election the share of valid votes received by the four candidates A, B, C, and D is represented by the pie chart shown. The total number of votes cast in the election were $1,15,000$, out of which $5,000$ were invalid

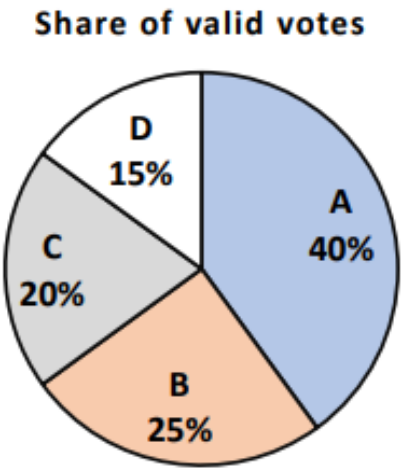


Fig. Q5..1: Sec figure

Based on the data provided, the total number if valid votes received by the candidates B and c is

a) $45,000$ b) $49,500$ c) $51,750$ d) $54,000$

Q6. Thousands of years ago, some people began dairy farming. This coincided with a number of mutations in a particular gene that resulted in these people developing the ability to digest dairy milk. Based on the given passage, which of the following can be inferred?

a) All human beings can digest diary milk.
b) No human being can digest diary milk.
c) Digestion of diary milk is essential for human beings.
d) In human beings, digestion of diary milk resulted from a mutuated gene.

Q7. The probability of a boy or a girl being born is 1/2. For a family having only three children, what is the probability of having two girls and one boy?

a) $3/8$ b) $1/8$ c) $1/4$ d) $1/2$

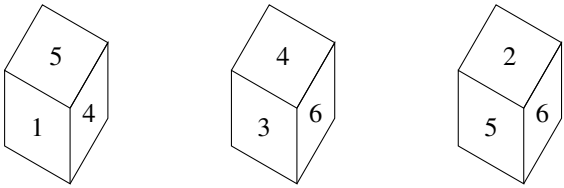
Q8. Person 1 and Person 2 invest in three mutual funds A, B, and C. The amounts they invested in each of these mutual funds are given in the table.

	Mutual fund A	Mutual fund B	Mutual fund C
Person 1	₹10,000	₹20,000	₹20,000
Person 2	₹20,000	₹15,000	₹15,000

At the end of one year, the total amount that Person 1 gets is ₹500 more than Person 2. The annual rate of return for the mutual funds B and C is 15% each. What is the annual rate of return for the mutual fund A?

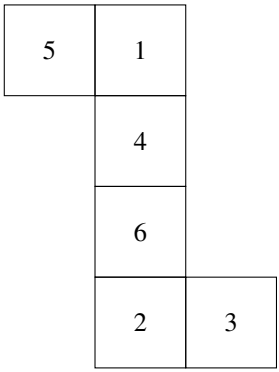
a) 7.5% b) 10% c) 15% d) 20%

Q9. Three different views of a dice are shown in the figure below.

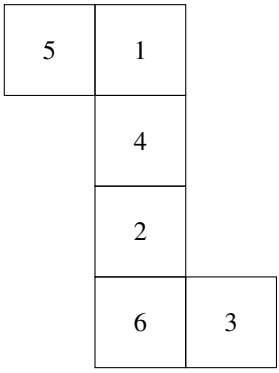


The piece of paper that can be folded to make this dice is

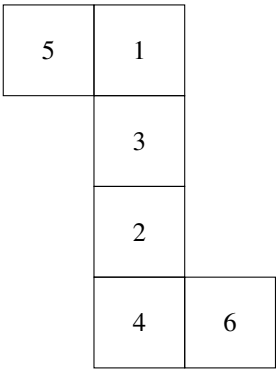
a)



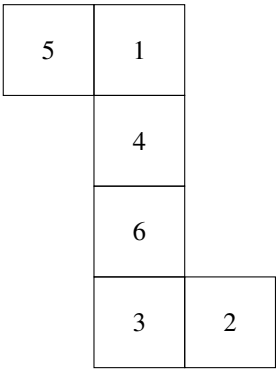
b)



c)



d)



Q10. Visualise two identical right circular cones such that one is inverted over the other and they share a common circular base. If a cutting plane passes through the vertices of the assembled cones, what shape does the outer boundary of the resulting cross-section make?

a) A rhombus b) A triangle c) An ellipse d) A hexagon

Q11. Ten cards in a pack are numbered as $1, 2, 3, ...10$. The probability of drawing a card with an even number or a number which is a multiple of 5 from the pack is _____.

a) $4/10$ b) $6/10$ c) $2/10$ d) $3/10$

Q12. Hardness of water is NOT caused by _____.

a) Ca^{2+} b) Si^{2+} c) Mg^{2+} d) CO_3^{2-}

Q13. The maximum coordination number of Sn^{4+} is _____

a) 4 b) 8 c) 6 d) 2

Q14. Rod shape bacterial cells are called _____.

a) Bacilli b) Cocci c) Spirilla d) Diplococci

Q15. Tuberculosis is predominantly caused by _____.

a) Entamoeba histolytica
b) Salmonella typhi
c) Mycobacterium bovis
d) Bacillus cereus

Q16. Which one of the following conversion belongs to nonsymbiotic nitrogen fixation?

a) Atmospheric nitrogen to ammonia by Rhizobium bacteria in nodules attached to roots of legumes
b) Atmospheric nitrogen to ammonia by Azotobacter species
c) Nitrate to gaseous nitrogen under anaerobic conditions
d) Nitrate to ammonia under aerobic conditions

Q17. Crown corrosion of reinforced cement sewer is caused by _____.

a) sulphur oxidising bacteria
b) iron oxidising bacteria
c) denitrifying bacteria
d) fermentative bacteria

Q18. The process of removal of particle in a rapid sand filter with their description is given in the table.

Process	Description
(i) Straining	P: Removes only particles in the water large enough to get caught in the pores of the filter
(ii) Sedimentation	Q: Larger and heavier particles do not follow the fluid streamline around the sand grain and settle on the grain
(iii) Interception	R: Particles that do follow the streamline, but are too large and are caught because they brush up against the sand grains
(iv) Diffusion	S: Very small particles are experiencing Brownian motion and may collide with the sand grains by chance

Select the correct match.

a) i- S; ii-P; iii-Q; iv-R
b) i-Q; ii-R; iii-S; iv-P
c) i-R; ii- S; iii- P; iv-Q
d) i-P; ii-Q; iii-R; iv-S

Q19. The environmental temperature increases by 6°C/km with height at a particular location. The stability condition of the atmosphere at the location is _____.

a) stable
b) unstable
c) inversion
d) neutral

Q20. As per the United Nations agenda for sustainable development adopted in September 2015,the number of Sustainable Development Goals (SDGs) are _____ and the proposed target year to achieve tehm is _____.

a) $15; 2035$
b) $17; 2030$
c) $20; 2050$
d) $18; 2047$

Q21. Which one of the following is NOT a greenhouse gas?

a) CO_2
b) CH_4
c) H_2S
d) H_2O

Q22. As per the United Nations Environmental Program (UNEP) guidelines 2004, the maximum size of microplastics is _____.

a) 10 mm
b) 5 mm
c) 10 μm
d) 5 μm

Q23. The costliest functional element in an urban centralized Muncipal Solid Waste management infrastructure for a typical Indian Tier I city is _____.

a) biological treatment
b) collection and transport
c) disposal in a sanitary landfill
d) thermal treatment

Q24. The eigen values of the matrix $\begin{bmatrix} 4 & 3 \\ 3 & 4 \end{bmatrix}$ are

a) 1 b) 2 c) 7 d) 4

Q25. If **X** is a vector, and **A** and **B** are linear operators; then the correct mathematical relationship(s) is/are

a) $(\mathbf{A}+\mathbf{B})\mathbf{X} = \mathbf{A}\mathbf{X} + \mathbf{B}\mathbf{X}$
b) $(\lambda\mathbf{A})\mathbf{X} = \lambda(\mathbf{A}\mathbf{X})$
c) $(\mathbf{A}\mathbf{B})\mathbf{X} = \mathbf{A}(\mathbf{B}\mathbf{X})$
d) $(\mathbf{A}+\mathbf{B})\mathbf{X} = \mathbf{A}^{\mathbf{T}}\mathbf{X} + \mathbf{B}^{\mathbf{T}}\mathbf{X}$

Q26. In the context of fluid flow, which of the following statement(s) is/are correct?

a) Streamline is a line, tangent to which at any point gives the direction of the velocity vector
b) Streakline is the actual path traversed by a given fluid particle in an unsteady flow
c) Streakline and streamline are same for a steady flow
d) Pathline and streamline are same for a steady flow

Q27. In a rectangular open channel, the flow is critical, and the flow depth is 2 m. Select the correct statement(s)

a) Specific energy for the flow is 3.0 m
b) Specific energy for the flow is 2.0 m
c) Froude number is 1.0
d) Froude number is 1.5

Q28. With respect to particle settling in wastewater treatment systems; the correct statement(s) is/are

a) Settling in grit chamber and primary sedimentation tanks are examples of Type-I settling
b) Settling in primary sedimentation tank and secondary sedimentation tank are examples of Type-II settling
c) Settling in grit chamber is an example of Type-I settling, whereas settling in primary sedimentation tank is an example of Type-II settling
d) Settling in secondary sedimentation tank is an example of Type-III settling, whereas settling in primary sedimentation tank is an example of Type-II settling

Q29. The equipment that can be used to control particulate air pollution in an industrial unit is/are

a) Electrostatic precipitator
b) Cyclone separator
c) Gravity settler
d) Incinerator

Q30. Which is/are the secondary air pollutant(s)?

a) O_3 b) HNO_3 c) CO_2 d) H_2SO_4

Q31. As per the Hazardous Waste (Management and Handling) Rules, 2016, of India, which is/are the characteristic(s) that must be exhibited by a waste to be classified as a "characteristic" hazardous waste?

a) Ignitability b) Reactivity c) Radioactivity d) Toxicity

Q32. f(x) = x^3 - 4.5x^2 - 12x has local maximum at x = _____(an integer value) in the range x = −2 to +2.

Q33. Consider the equation $\frac{dy}{dx} - x^2 + e^x = 0$; with y=1 at x=0. The value of y at x=1 is _____(rounded off to 2 decimal places). Take the value of e (base of natural logarithm) as 2.7.

Q34. A municipal solid waste digester generates 1000 kg of methane gas. The volume of the tank needed to store this gas at 30°C and 3 atmospheric pressure is _____ liters (an integer value). Use R=0.082 L-atm/mole-K, Atomic weights of C=12, and H=1

Q35. A Class-A pan was setup adjacent to a lake for measuring evaporation losses in the lake. The depth of water in the pan at the beginning of a certain week was 250 mm. In that week, there was a rainfall event with 10 mm depth. Water depth in the pan at the end of the week was 240 mm. The pan coefficient is 0.8.

The estimated lake evaporation during the week was _____ mm (an integer value).

Q36. A population (with mean μ) follows normal distribution. Ten samples (N) are drawn at random with a mean value of "x" and standard deviation of "S". Following table provides the confidence limits, C(t) of the cumulative probability function for Student's t distribution two-tailed test with degree of freedom, D.

Which one of the following expression is correct for testing the null hypothesis H_0: $\mu = 0$ at 10% significance level?

D	**C(t)**		
	0.9	**0.95**	**0.975**
9	1.38	1.83	2.26
10	1.37	1.81	2.23
11	1.36	1.80	2.20

a) $-1.81 < \frac{x}{\frac{S}{\sqrt{N-1}}} < 1.81$

b) $-1.83 < \frac{x}{\frac{S}{\sqrt{N-1}}} < 1.83$

c) $-1.37 < \frac{x}{\frac{S}{\sqrt{N-1}}} < 1.37$

d) $-2.23 < \frac{x}{\frac{S}{\sqrt{N-1}}} < 2.23$

Q37. Which one is the solution y(x) for the following ordinary differential equation and the specified boundary conditions?

$$\frac{d^2y}{dx^2} - 3\frac{dy}{dx} + 2y = 2e^{-x}, \quad y(0) = 2; \quad \left(\frac{dy}{dx}\right)_{x=0} = 1$$

a) $$y(x) = \frac{1}{3}e^{-x} - 2e^{x} - \frac{1}{3}e^{2x}$$

b) $$y(x) = \frac{1}{3}e^{x} + 2e^{x} - \frac{1}{3}e^{2x}$$

c) $$y(x) = \frac{1}{3}e^{-x} + 2e^{-x} - \frac{1}{3}e^{2x}$$

d) $$y(x) = \frac{1}{3}e^{-x} + 2e^{x} - \frac{1}{3}e^{2x}$$

Q38. A saturated CaCO3 stock solution is existing at 25°C. In one experiment (i) 25 g Na_2CO_3 is added to the stock solution. In another experiment (ii) 25 g Na_2SO_4 is added to the stock solution. Select the correct statement from the following

a) Addition of (i) increases the concentration of Ca^{2+} and addition of (ii) decreases the concentration of Ca^{2+}
b) Addition of (i) decreases the concentration of Ca^{2+} and addition of (ii) increases the concentration of Ca^{2+}
c) Addition of (i) and (ii) increases the concentration of Ca^{2+}
d) Addition of (i) and (ii) decreases the concentration of Ca^{2+}

Q39. Consider second order kinetics ($r_c = -kC^2$ under steady state condition. The ratio of volume of a complete mixed reactor (CMR) to that of a plug flow reactor (PFR) to achieve 90% reduction in the concentration is _____.
Inlet concentrations in both the reactors are same.

a) 10.0 b) 1.0 c) 0.1 d) 2.3

Q40. Consider two horizontal layers of an aquifer as shown in figure. Each layer is isotropic and homogeneous. Flow is parallel to the stratification. Thickness and horizontal hydraulic conductivity of layer-1 are h_1 and K_1, respectively. Thickness and horizontal hydraulic conductivity of layer-2 are h_2 and K_2, respectively, where h_1 is not equal to h_2. The equivalent horizontal conductivity K_x for the aquifer system is given by

_____

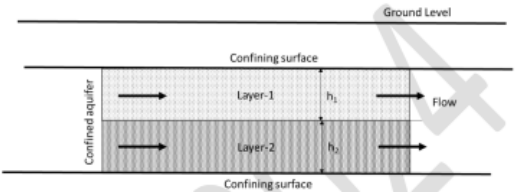


Fig. Q40..1: Third figure

a) $K_x = \dfrac{K_1 h_1 + K_2 h_2}{h_1 + h_2}$

b) $K_x = \dfrac{K_1 + K_2}{2}$

c) $K_x = \dfrac{K_1 h_2 + K_2 h_1}{h_1 + h_2}$

d) $K_x = \sqrt{K_1 K_2}$

Q41. A gravity settling chamber of height 'H' and length 'L' is designed to control particulate air pollution. In the chamber, the horizontal velocity of air flow is 'V_h' and terminal settling velocity of the target particle is 'V_t'. Which one of the following expressions is the correct concept used to calculate the minimum size of the target particle that will be removed with 100% efficiency?

a) $\frac{V_t}{L} = \frac{V_h}{H}$ b) $V_h \times V_t = L \times H$ c) $V_h = V_t \times L \times H$ d) $\frac{V_t}{H} = \frac{V_h}{L}$

Q42. Consider the function $f(x) = ln(sin(x))$. Expand $f(x+h)$ usin Taylor's series. In this context, the correct statement(s) is/are

a) Second term in the Taylor's series i.e., the term which includes h is: h.$ln(sin(x))$
b) First term is $ln(sin(x))$
c) Third term in the Taylor's series i.e., the term which includes h^2 is: $\frac{-h^2}{2(sin(x))^2}$
d) Third term in the Taylor's series i.e., the term which includes h^2 is: $\frac{2h^2}{(sin(x))^2}$

Q43. Enzymes with the class of enzymes are listed in the table.

Enzyme	**Class of Enzyme**
(a) Lactate dehydrogenase	(i) Isomerases
(b) Alanine racemase	(ii) Transferases
(c) Lipase	(iii) Oxidoreductases
(d) Hexokinase	(iv) Hydrolases

Select the correct match(es)

a) (a) - (iii); (b) - (i)
b) (c) - (iv); (d) - (ii)
c) (a) - (ii); (b) - (iv)
d) (c) - (iii); (d) - (i)

Q44. With reference to disinfection,which of the following statement(s) is/are **CORRECT**?

a) Ethanol damages lipid structures in the bacterial cell membrane.
b) Mercuric chloride inactivates cellular enzymes containing sulfhydryl groups.
c) Glutaraldehyde inactivates protein.
d) Isopropyl alcohol cannot be used as a disinfectant.

Q45. Which of the following statement(s) is/are **CORRECT**?

a) DNA is composed of nucleotides
b) Five types of nitrogenous bases occur in DNA
c) Each phosphate is attached to two deoxyribose units in a single strand of DNA.
d) The ratio of adenine to guanine is always 1 : 1 in a double stranded DNA.

Q46. The Streeter Phelp's oxygen sag equation for a river is based on a few assumptions. The correct assumption(s) is/are

a) At any instant the deoxygenation rate is directly proportional to the amount of oxidizable organic material present.
b) At any instant the deoxygenation rate is inversely proportional to the amount of oxidizable organic material present.
c) The reoxygenation rate is directly proportional to the dissolved oxygen deficit
d) The reoxygenation rate and deoxygenation rate are directly proportional to the saturation concentration of dissolved oxygen

Q47. Water is flowing **FULL** through a rectangular tunnel of size 3 m (width) × 2 m (height). The average velocity of flow is 1 m/s. The frictional head loss is observed to be 1 m per km. Consider acceleration due to gravity (g) as 10 m/s^2. The correct statement(s) is/are

a) Hydraulic radius is 0.6 m
b) Darcy-Weisbach friction factor is 0.048
c) Hydraulic radius is 2 m
d) Darcy-Weisbach friction factor is 0.024

Q48. Based on the ISO 14040 methodology for Life Cycle Assessment, match the terms with the descriptions in the table.

Term	**Description**
(a) Goal and Scope	(i) Based on the product or system, the comparative unit must be carefully defined and be same for all scenarios
(b) Functional Unit	(ii) The problem is described, and the objective of the study are defined
(c) Life Cycle Inventory	(iii) Evaluates the environmental implications due to the inventorized emissions
(d) Impact Assessment	(iv) Process based approach and input–output approach

a) (a)-(ii); b-(i); b) (a)-(iii), b-(i) c) (c)-(iii), (d)-(iv) d) (c)-(iv), (d)-(iii)

Q49. Consider the equation for a curve, $y = f(x) = x^2 + x$.

The area enclosed by the curve, the x -axis (y= 0 line); the vertical lines passing through x = 1 and x = 2 is _____(rounded off to 2 decimal places)

Q50. The pH of a solution containing 0.1M of acetic acid and 0.05 M of sodium acetate is _____ (rounded off to 2 decimal places).

The pKa value of ionization of acetic acid is 4.76.

Q51. The ionic strength of a solution containing 0.01M of $CaCl_2$ and 0.001M of Na_2SO_4 is _____M (rounded off to 3 decimal places).

Q52. The concentration of Ozone corresponding to a mixing ratio of 120 ppbv at pressure of 1 atmosphere and temperature of 25°C is _____ $\mu g/m^3$ (rounded off to 1 decimal place). Atomic weight of oxygen = 16; R= 8.314 J/K-g.mole.

Q53. One million liters per day (MLD) of wastewater with a soluble BOD of 200 mg/L is treated in an activated sludge process. The BOD of treated wastewater is 20 mg/L. The observed yield coefficient of the biological system is 0.35.

The daily biomass generation in the system is _____ kg (an integer value).

Q54. An industry discharges 2 million liters per day (MLD) of wastewater with a temperature of 45°C and a pH of 2, whereas the neighboring industry produces 3 MLD of wastewater with a temperature of 30°C and pH of 8. If both the wastewaters are mixed and carried through a pipeline, then the resultant pH of mixed wastewater is _____(rounded off to 2 decimal places).

Neglect buffering capacity of the system and the temperature effect on pH.

Q55. Consider a watershed and isohyets as shown in the figure. The average rainfall in the watershed is _____ mm (an integer value).

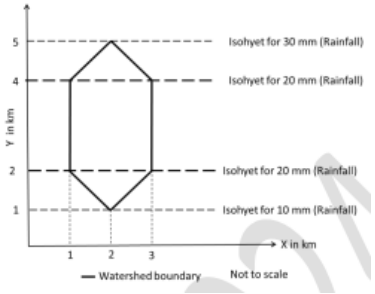


Fig. Q55..1: Fourth figure

Q56. With reference to the gate shown in the figure, the gate will start opening automatically when the water level 'h' above the hinge is _____m (rounded off to 2 decimal places).

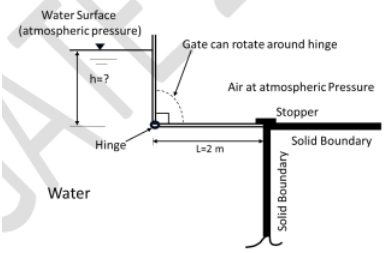


Fig. Q56..1: Fifth figure

Q57. In a cyclone separator of radius 25 cm, a particle is travelling with a gas stream at velocity of 18 m/s. The ratio of centrifugal force to the gravitational force acting on the particle is _____ (rounded off to 2 decimal places).
Consider acceleration due to gravity (g) as 9.8 m/s^2.

Q58. Two sources of noise, adjacent to each other in a room, have sound pressure levels of 30 and 40 decibel (dB). The combined sound pressure level in the room is _____ dB (rounded off to 2 decimal places).

Use reference sound pressure as 20μPa.

Q59. An industrial stack emits 100 g/s of CO at an effective height of 'H', where the wind speed is 5 m/s. At 3 km distance downwind, the values of dispersion coefficient in y-direction and z-direction are 50 m and 25 m, respectively. The CO concentration at the centerline of the plume at 3 km distance downwind is _____mg/m^3 (rounded off to 2 decimal places)?

Use Gaussian plume model and value of π = 3.14. Neglect reactions and the ground effect of plume in the calculations.

Q60. Two hypothetical organic waste streams A and B are mixed prior to the composting process. Waste-A has 2.16% of C and 1.20% of N. Waste-B has 19.10% of C and 0.14% of N. The quantity of Waste-B that should be mixed with per kg of Waste-A to achieve the desired C:N ratio of 25 is _____kg (rounded off to 2 decimal places).
Assume both the waste streams are completely dry.

Q61. Food waste, paper waste and plastic waste have typical densities of 280 kg/m^3 , 80 kg/m^3 , and 50 kg/m^3 , respectively. The mixed waste is composed of 70% food waste, 20% paper waste and 10% plastic waste. The density of the mixed waste is _____kg/m^3 (rounded off to 2 decimal places). Neglect compaction effect.

Q62. For a biodegradable waste with a chemical formula $C_{50}H_{100}N_{40}$, the maximum theoretical methane production per ton of waste is _____ kg (rounded off to 2 decimal places). Assume 100% anaerobic conversion. Atomic weights of C-12; H-1; O-16; N-14

Q63. A person consumes 2.5 liters of water per day. The water quality test indicated that the supplied water has a Pb concentration of 0.6 mg/L. If the weight of the person is 75 kg, the exposure level for Pb for this person from this drinking water source is _____ mg/kg/day (rounded off to 2 decimal places).

Q64. In a region, total annual consumption of gasoline is 30.6 million tons. The land required for growing sugarcane to produce enough bioethanol to replace the gasoline completely is _____ km^2 (an integer value).
Ethanol energy equivalent is 67% of gasoline, gasoline density is 850 kg/m^3 , yield of bioethanol produced from sugarcane per hectare of land is 3750 L, and 1 km^2 = 100 hectares.

Q65. Initially a bottle contained 400 g of ethanol. Half of ethanol was used by a student for preparing the stock solution in an environmental chemistry laboratory just before summer vacation of 90 days. After completing the procedure, the student left the bottle uncorked. If the unsealed bottle losses ethanol at a rate of 0.5 g/day, the ethanol that will be left in the bottle at the end of the summer vacation is _____ g (an integer value).