# Environmental Science and Engineering(ES)

1) Rafi told Mary, "I am thinking of watching a film this weekend." The following reports on the above statement in indirect speech:

Rafi told Mary that _____ of watching a film that weekend.

a) thought
b) is thinking
c) am thinking
d) was thinking

(GATE ES 2023)

2) Permit : _____ :: Enforce : Relax

(By word meaning)

a) Allow
b) Forbid
c) License
d) Reinforce

(GATE ES 2023)

3) Given a fair six-faced dice where the faces are labelled '1', '2', '3', '4', '5', and '6', what is the probability of getting a '1' on the first roll of the dice and a '4' on the second roll?

a) $\frac{1}{36}$ 　　　　 b) $\frac{1}{6}$ 　　　　 c) $\frac{5}{6}$ 　　　　 d) $\frac{1}{3}$

(GATE ES 2023)

4) A recent survey shows that 65% of tobacco users were advised to stop consuming tobacco. The survey also shows that 3 out of 10 tobacco users attempted to stop using tobacco.

Based only on the information in the above passage, which one of the following options can be logically inferred with certainty?

a) A majority of tobacco users who were advised to stop consuming tobacco made an attempt to do so.
b) A majority of tobacco users who were advised to stop consuming tobacco did not attempt to do so.
c) Approximately 30% of tobacco users successfully stopped consuming tobacco.
d) Approximately 65% of tobacco users successfully stopped consuming tobacco.

(GATE ES 2023)

5) How many triangles are present in the given figure?
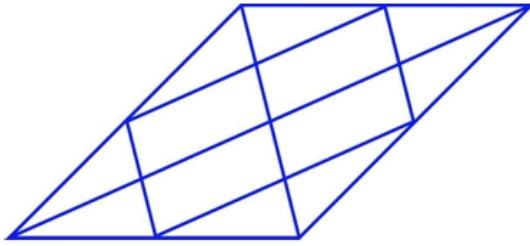


   a) 12
   b) 16
   c) 20
   d) 24

<div align="right">(GATE ES 2023)</div>

6) Students of all the departments of a college who have successfully completed the registration process are eligible to vote in the upcoming college elections. However, by the time the due date for registration was over, it was found that surprisingly none of the students from the Department of Human Sciences had completed the registration process.

Based only on the information provided above, which one of the following sets of statement(s) can be logically inferred with certainty?

(i) All those students who would not be eligible to vote in the college elections would certainly belong to the Department of Human Sciences.

(ii) None of the students from departments other than Human Sciences failed to complete the registration process within the due time.

(iii) All the eligible voters would certainly be students who are not from the Department of Human Sciences.

   a) (i) and (ii)
   b) (i) and (iii)
   c) only (i)
   d) only (iii)

<div align="right">(GATE ES 2023)</div>

7) Which one of the following options represents the given graph?
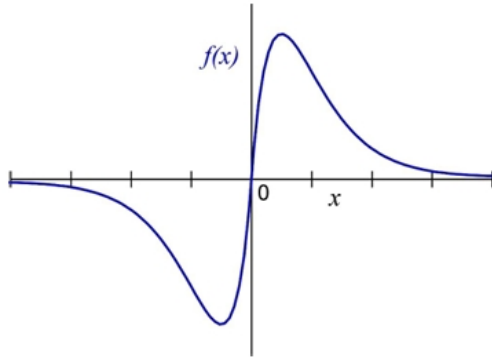


a) $f(x) = x^2 2^{-|x|}$
b) $f(x) = x\, 2^{-|x|}$
c) $f(x) = |x|\, 2^{-x}$
d) $f(x) = x\, 2^{-x}$

(GATE ES 2023)

8) Which one of the options does NOT describe the passage below or follow from it?

We tend to think of cancer as a 'modern' illness because its metaphors are so modern. It is a disease of overproduction, of sudden growth, a growth that is unstoppable, tipped into the abyss of no control. Modern cell biology encourages us to imagine the cell as a molecular machine. Cancer is that machine unable to quench its initial command (to grow) and thus transform into an indestructible, self-propelled automaton.

*[Adapted from The Emperor of All Maladies by Siddhartha Mukherjee]*

a) It is a reflection of why cancer seems so modern to most of us.
b) It tells us that modern cell biology uses and promotes metaphors of machinery.
c) Modern cell biology encourages metaphors of machinery, and cancer is often imagined as a machine.
d) Modern cell biology never uses figurative language, such as metaphors, to describe or explain anything.

(GATE ES 2023)

9) The digit in the unit's place of the product $3^{999} \times 7^{1000}$ is _____.

    a) 7
    b) 1
    c) 3
    d) 9

<div align="right">(GATE ES 2023)</div>

10) A square with sides of length 6 cm is given. The boundary of the shaded region is defined by two semi-circles whose diameters are the sides of the square, as shown. The area of the shaded region is _____ cm$^2$.
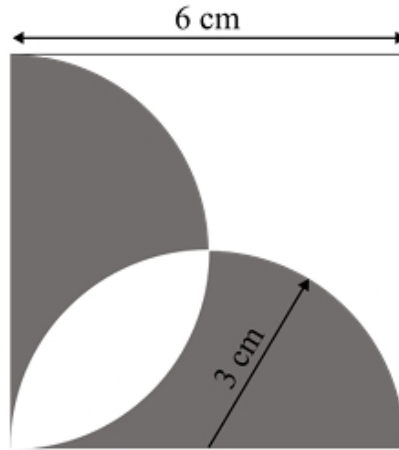


    a) $6\pi$
    b) 18
    c) 20
    d) $9\pi$

<div align="right">(GATE ES 2023)</div>

11) Given are two ordinary differential equations

P: $\frac{dy}{dx} + x = x \sin y$

Q: $\frac{dy}{dx} + xy = e^x y$

The correct choice is

a) P is linear; Q is nonlinear
b) P is nonlinear; Q is linear
c) Both P and Q are linear
d) Both P and Q are nonlinear

(GATE ES 2023)

12) $\mathbf{P}$ and $\mathbf{Q}$ are square matrices. Consider the following

X: $(\mathbf{P}^{-1})^{-1} = \mathbf{P}$

Y: Symmetric if $\mathbf{Q} = -\mathbf{Q}^T$

The correct choice is

a) X is TRUE; Y is FALSE
b) X is FALSE; Y is TRUE
c) Both X and Y are TRUE
d) Both X and Y are FALSE

(GATE ES 2023)

13) Given are two infinite series

P: $\sum \frac{n^2+1}{n^2}$

Q: $\sum \left(1 + \frac{1}{n}\right)^{-n}$

The correct choice is

a) P is convergent series; Q is divergent series
b) P is divergent series; Q is convergent series
c) Both P and Q are convergent series
d) Both P and Q are divergent series

(GATE ES 2023)

14) For testing alkalinity for a water sample, first phenolphthalein indicator is added. The water remains colorless. However, when a few drops of methyl orange is added to the sample, the colour turns yellow. As per these observations, the correct choice is

a) Absence of $CO_3^{2-}$ and/or $HCO_3^-$ but the presence of $OH^-$ ions in the sample
b) Presence of $CO_3^{2-}$ and/or $HCO_3^-$ but the absence of $OH^-$ ions in the sample
c) Absence of $CO_3^{2-}$, $HCO_3^-$ and $OH^-$ ions in the sample
d) Presence of $CO_3^{2-}$, $HCO_3^-$ and $OH^-$ ions in the sample

15) Read the following statements
   I. Photosynthesis takes place within the chloroplasts of the eukaryotes, whereas the breakdown of complex molecules to yield energy takes place in the cytoplasm and in the mitochondria.
   II. Photosynthesis takes place within the chloroplasts of the prokaryotes, whereas the breakdown of complex molecules to yield energy takes place in the cytoplasm and in the mitochondria.
   III. All living organisms retain the enzymatic machinery to partially oxidise glucose without the help of oxygen. This breakdown of glucose to pyruvic acid is called glycolysis.
   IV. All living organisms retain the enzymatic machinery to completely oxidise glycerol without the help of oxygen. This breakdown of glycerol to citric acid is called glycolysis.

   The correct choice is

   a) I and III are correct
   b) II and IV are correct
   c) I is correct whereas III is incorrect
   d) II is correct whereas IV is incorrect

   (GATE ES 2023)

16) Read the following statements
   i. Aerobic heterotrophic bacteria uses organic matter for carbon source and energy source.
   ii. Aerobic heterotrophic bacteria uses carbon dioxide for carbon source and energy source.
   iii. Aerobic autotrophic bacteria uses carbon dioxide for carbon source and reduced substances for energy source.
   iv. Aerobic autotrophic bacteria uses organic matter for getting energy.

   The correct choice is

   a) ($i$) is correct; ($iii$) is correct
   b) ($iv$) is correct; ($i$) is incorrect
   c) ($i$) is correct; ($iv$) is correct
   d) ($ii$) is correct; ($iv$) is incorrect

   (GATE ES 2023)

17) A student wants to decide electron acceptor for aerobic, facultative and anaerobic bacteria. In this context, read the following statements
   i. Dissolved Oxygen (*DO*) can act as electron acceptor for aerobic bacteria.
   ii. Nitrite can act as electron acceptor for aerobic bacteria.
   iii. Dissolved Oxygen (*DO*) can act as electron acceptor for anaerobic bacteria.
   iv. Nitrite can act as electron acceptor for facultative bacteria.

   The correct choice is

   a) ($i$) is correct; ($iv$) is correct
   b) ($ii$) is correct; ($iii$) is incorrect
   c) ($i$) is correct; ($iii$) is correct
   d) ($i$) is correct; ($ii$) is correct

   (GATE ES 2023)

18) Which of the following is true according to the Central Pollution Control Board ($CPCB$), Government of India's notification issued in the year 2009?

   a) 24 hour averaged standard for $PM_{2.5}$ in ambient air is 60 $\mu g/m^3$; 24 hour averaged standard for $PM_{10}$ in ambient air is 100 $\mu g/m^3$

   b) 24 hour averaged standard for $PM_{2.5}$ in indoor air is 60 $\mu g/m^3$; 24 hour averaged standard for $PM_{10}$ in ambient air is 100 $\mu g/m^3$

   c) 24 hour averaged standard for $PM_{2.5}$ in ambient air is 60 $\mu g/m^3$; 24 hour averaged standard for $PM_{10}$ in indoor air is 100 $\mu g/m^3$

   d) 24 hour averaged standard for $PM_{2.5}$ in indoor air is 60 $\mu g/m^3$; 24 hour averaged standard for $PM_{10}$ in indoor air is 100 $\mu g/m^3$

(GATE ES 2023)

19) The sub index values of $NO_2$, $SO_2$ and $PM_{10}$ are 80, 80 and 100, respectively. According to the National Air Quality Index ($NAQI$) released by the Government of India in the year 2015, the overall NAQI is

   a) 80
   b) 260
   c) 100
   d) 151

(GATE ES 2023)

20) Which of the following is NOT a designated waste category under Bio-medical Waste Management Rules, 2016 of Government of India?

   a) Yellow
   b) Green
   c) Red
   d) Blue

(GATE ES 2023)

21) Consider the following waste categories

   i. Domestic Hazardous Waste
   ii. Nuclear Waste
   iii. Sludge from wet scrubbers of hazardous waste treatment processes
   iv. Chromium bearing residue and sludge from leather tanneries

   Which one of the options correctly represents the waste categories NOT covered under Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 of Government of India?

   a) (*i*) and (*ii*) only
   b) (*i*) and (*iii*) only
   c) (*ii*) and (*iv*) only
   d) (*i*), (*ii*) and (*iii*) only

(GATE ES 2023)

22) Match the following

| **Plastic Type** | **Common applications** |
| --- | --- |
| P. High-density polyethylene (*HDPE*) | (*i*) Garbage bags, bubble packaging |
| Q. Low-density polyethylene (*LDPE*) | (*ii*) Pharmaceutical bottles, Styrofoam cups |
| R. Polyethylene terephthalate (*PET*) | (*iii*) Water bottles |
| S. Polystyrene (*PS*) | (*iv*) Geomembrane for landfill liner |

   a) P − (iv), Q − (i), R − (iii), S − (ii)
   b) P − (i), Q − (iii), R − (ii), S − (iv)
   c) P − (iv), Q − (ii), R − (i), S − (iii)
   d) P − (ii), Q −(iii), R − (iv), S − (i)

23) Place the following international conventions/conferences/protocols/declarations in the chronological order (oldest to latest) of their happening

  i. United Nations conference in Stockholm which resulted in the establishment of the United Nations Environmental Program (*UNEP*)
  ii. Vienna convention for the protection of the Ozone layer
  iii. United Nations climate change conference in Glasgow commonly referred as COP26
  iv. Montreal protocol on phasing out production of substances related to Ozone layer depletion

  The correct choice is

   a) i, ii, iv, iii
   b) i, ii, iii, iv
   c) ii, iv, i, iii
   d) iv, iii, ii, i

24) The correct ascending order of the following greenhouse gases with respect to their global warming potential relative to $CO_2$ in the time horizon of 100 years is

   a) $CH_4 < N_2O < CFCl_3 < CF_2Cl_2$
   b) $CF_2Cl_2 < CH_4 < N_2O < CFCl_3$
   c) $CH_4 < N_2O < CF_2Cl_2 < CFCl_3$
   d) $N_2O < CFCl_3 < CH_4 < CF_2Cl_2$

25) Read the following statements with reference to the Kyoto Protocol on Climate Change

   i. Each signatory (*country*) has common and equal responsibility.

   ii. Clean development mechanism (*CDM*), joint implementation (*JI*) and international emission trading are the three mechanisms under Kyoto Protocol to reduce the greenhouse gas emissions.

   iii. Under Kyoto Protocol, India has agreed to reduce its greenhouse gas emissions by half by 2050 as compared to 2005 emissions.

Which one of the following is correct choice?

a) only (*i*) is TRUE

b) only (*ii*) is TRUE

c) only (*i*) and (*ii*) are TRUE

d) only (*ii*) and (*iii*) are TRUE

26) Read the following statements

   I. In environmental laws, the polluter pays principle is enacted to make the polluter responsible for paying for the damage done to the natural environment.

   II. The precautionary principle emphasizes caution, pausing and review before going for an innovation that may prove disastrous.

   III. The precautionary principle is often used by policy makers in situations where there is the possibility of harm from making a certain decision and conclusive evidence is not yet available.

The correct choice is

a) I is correct; II and III are incorrect

b) I, II and III are correct

c) I and III are correct; II is incorrect

d) I and II are correct; III is incorrect

27) Read the following statements

   I. The goal of Life Cycle Analysis (*LCA*) is to assess the environmental impact of products from a system perspective and to identify possible improvement strategies.

   II. Environmental Impact Assessment (*EIA*) is defined as a process of identifying, predicting, and evaluating the likely impacts of a proposed project or development to define mitigation actions to reduce negative impacts and to provide positive contributions to the natural environment and well-being.

The correct choice is

a) I is correct; II is incorrect

b) II is correct; I is incorrect

c) Both I and II are correct

d) Both I and II are incorrect

28) For the following major Indian environmental acts
   i) Environmental Protection Act
   ii) Water Act (Prevention and Control of Pollution)
   iii) Air Act (Prevention and Control of Pollution)
   iv) The National Green Tribunal Act

   the correct chronological order (oldest to latest of their enactment) is
   a) i, ii, iii, iv
   b) ii, i, iii, iv
   c) iii, i, iv, ii
   d) ii, iii, i, iv

(GATE ES 2023)

29) The kinematic viscosity of glycerin and kerosene are 1.2 times and 0.95 times of that of water, respectively. Glycerin and kerosene flow through two identical porous media having same hydraulic gradient. Assuming Darcy's law is valid for the porous media, the ratio of flow rate of kerosene to that of glycerin is
   a) 1.052
   b) 1.140
   c) 0.792
   d) 1.263

(GATE ES 2023)

30) A researcher compiled the following information about the performance of a kit in an outbreak

| | Infection state | Kit response |
|---|---|---|
| Disease (probability = 0.002) | Positive response (probability = 0.98) | |
| No Disease | Positive response (probability = 0.03) | |

The probability of detecting an infection for a positive result through the kit would be _ _ _ _ _ _ _ _ _ _ _ _ _ (rounded off to three decimal places). (GATE ES 2023)

31) The critical depth in a 2 m wide rectangular channel carrying a discharge of 10 m$^3$/s and taking value of acceleration due to gravity ($g$) as 9.81 m/s$^2$ is _ _ _ _ _ _ _ _ (in m, rounded off to two decimal places). (GATE ES 2023)

32) The ratio of the moles of $CO_2$ evolved to the moles of $O_2$ consumed in respiration also called the respiratory quotient, is calculated for a carbohydrate $C_6H_{12}O_6$ as substrate and found to be 1. Under similar conditions, for a fatty acid $C_{51}H_{98}O_6$ as substrate, the respiratory quotient is _ _ _ _ _ _ _ _ (rounded off to two decimal places). (GATE ES 2023)

33) The value of $\frac{4}{\pi} \int_0^{\pi/2} \sin^2 x \, dx$ is _ _ _ _ _ _ _ _ (rounded off to two decimal places). (GATE ES 2023)

34) An S-hydrograph was prepared for a catchment of 240 km$^2$ using 3-hour unit hydrograph (1 cm rainfall excess). The equilibrium discharge for the S-hydrograph would be _ _ _ _ _ _ _ _ (in m$^3$/s, rounded off to two decimal (GATE ES 2023)

35) River water containing two types of spherical suspended particles (clay particles, metal particles) is retained in a sedimentation tank. The clay particles having diameter of 75 $\mu$m and specific gravity of 2.65 is settling in the tank with a constant velocity. The velocity of clay particles is 2 times of that of metal particles having specific gravity of 8. Assume discrete settling and laminar flow conditions within the sedimentation tank. The estimated diameter of the metal particles is _ _ _ _ _ _ _ _ _ _ _ (in $\mu$m, rounded off to integer).                    (GATE ES 2023)

36) W1, W2, W3, W9 represent the holding times of 9 water samples, which follow a normal distribution with mean = 8.33 and standard deviation = 4.472. M represents the sample mean value of holding times, which also has a normal distribution. Assuming Z has a standard normal distribution (mean = 0 and standard deviation = 1), select the correct statement which describes the expression for calculating the value of type 1 error where

null hypothesis ($H_0$):     M > 6
alternate hypothesis ($H_a$):     M $\leq$ 6

a) P{Z < (-1.565)}
b) P{Z < 1.565}
c) P{Z > (-1.565)}
d) P{Z > 1.565}

(GATE ES 2023)

37) Which one of the following statements is NOT correct?

a) Photophosphorylation is the synthesis of ATP from ADP and inorganic phosphate in the presence of light.
b) The process through which ATP is synthesised by cells (in mitochondria and chloroplasts) is called phosphorylation.
c) The Calvin cycle (carboxylation, reduction, and regeneration) occurs in all photosynthetic plants (C3, C4 or any other).
d) C3 plants have a special type of leaf anatomy, they tolerate higher temperatures, they show a response to high light intensities, have high rate of photosynthesis and reduced rate of photorespiration as compared to C4 plants.

(GATE ES 2023)

38) Read the following statements

   I. Bacteriophage is an anaerobic bacterium.
  II. Male-specific bacteriophage infect via the pili of other microorganisms including viruses.
 III. Bacteriophage is found in human as well as in animal excreta.
 IV. Bacteriophage can not indicate the presence of bacteria.

   The correct choice is

   a) I, III and IV are correct
   b) IV is correct; III is incorrect
   c) Both III and IV are incorrect
   d) Both III and IV are correct

(GATE ES 2023)

39) Read the following statements

   i) In endogenous metabolism by aerobic bacteria, electron acceptor is present inside the cells.
  ii) In endogenous metabolism by aerobic bacteria, electron acceptor is dissolved oxygen.
 iii) The endogenous metabolism is linked to fermentative metabolism.
 iv) In exogenous metabolism by aerobic bacteria, enzyme mediated electron transfer happens within the cells.

   The correct choice is

   a) i is correct; iii is correct
   b) ii is correct; iii is incorrect
   c) iii is incorrect; iv is incorrect
   d) iii is correct; iV is correct

(GATE ES 2023)

40) A boiler in an industry, located where high plume rise is expected, releases flue gas with fine particulate matter. Which one of the following options is most suited and efficient if this particulate matter is intended for reuse?

   a) reduce stack height and increase stack diameter
   b) use of wet collectors
   c) use of flue gas desulfurization (FGD)
   d) use of electrostatic precipitator (ESP)

(GATE ES 2023)

41) Match the following
   J) Dalton's law   i) Diffusion
   K) Fick's law     ii) Pressure exerted by a mixture of gases
   L) Henry's law    iii) Gravitational settling
   M) Stoke's law    iv) Gas-liquid phase transfer

   a) J − ii; K − i; L − iv; M − iii
   b) J − iii; K − ii; L − i; M − iv
   c) J − ii; K − iii; L − iv; M − i
   d) J − i; K − iv; L − ii; M − iii

(GATE ES 2023)

42) Read the following statements
   I. According to the Liebig's law of minimum, the growth is regulated by the limited factors i.e., resources in scarcity and not by the resources in abundance.
   II. Shelford's law of tolerance states that, only the factors present in excess/abundance can affect the growth, development of an organism or rate of biological process.
   III. Shelford's law of tolerance states that, an organism's success is based on a complex set of conditions and that each organism has a certain minimum, maximum, and optimum levels of environmental factor or combination of factors that determine success.

   The correct choice is

   a) I and II are correct; III is incorrect
   b) I and III are correct; II is incorrect
   c) II is correct; I and III are incorrect
   d) III is correct; I and II are incorrect

(GATE ES 2023)

43) Read the following statements
   I. Trivalent chromium has relatively low aqueous solubility, and low mobility in the soil environment. By contrast, hexavalent chromium has a higher aqueous solubility and greater mobility in the soil environment.
   II. The chemical reaction between trivalent chromium and zero-valent iron will result in transformed version called hexavalent chromium.
   III. Hexavalent chromium is a known carcinogen.
   IV. Trivalent chromium has relatively higher human toxicity as compared to hexavalent chromium.

   The correct choice is

   a) IV is correct; I and III are incorrect
   b) II is correct; I and IV are incorrect
   c) I and III are correct; II and IV are incorrect
   d) I, II and IV are correct; III is incorrect

(GATE ES 2023)

44) Which of the following statements is/are NOT true?

    a) Urban heat island effect in a city can be reduced by increasing trees and vegetation cover in the city.

    b) Urban heat island intensity is affected by $PM_{2.5}$ concentrations in a city.

    c) Urban heat island intensity increases due to installation of reflective roofs in a city.

    d) In comparison with the non-urban areas, urban heat island effect raises night-time temperatures more than daytime temperatures in cities.

<div align="right">(GATE ES 2023)</div>

45) Read the following statements about aerobic composting of organic fraction of municipal solid waste

    I. The majority of the odour problem in an aerobic composting process is due to the development of anaerobic conditions within the compost pile.

    II. All organic carbon present in the waste will completely biodegrade in 14 days.

    III. At high C/N ratio, ammonia would be released and biological activity may also be impeded.

    IV. Optimum moisture content for aerobic composting process would be 50–60%. Lower moisture would slow down the biological process. Excessive moisture will make it difficult to maintain aerobic conditions.

  The correct choice(s) is/are

    a) I and IV are correct

    b) II and III are incorrect

    c) I is correct; IV is incorrect

    d) II is correct; IV is incorrect

<div align="right">(GATE ES 2023)</div>

46) Products P and Q have life cycle phases of material extraction, production, use, and end of life disposal. $CH_4$, $CO_2$ emissions and mass used per functional unit (f.u). from the different phases of the products are given in the following tables.

**Product P**

| Phase | $CO_2$ emissions, kg/tonne | $CH_4$ emissions, kg/tonne | Mass, tonne/functional unit |
|---|---|---|---|
| Material Extraction | 1.0 | 0.75 | 4.0 |
| Production | 1.5 | 1.0 | 2.0 |
| Use | 0.5 | 0.0 | 3.0 |
| End of life disposal | 1.0 | 0.25 | 1.0 |

**Product Q**

| Phase | $CO_2$ emissions, kg/tonne | $CH_4$ emissions, kg/tonne | Mass, tonne/functional unit |
|---|---|---|---|
| Material Extraction | 0.75 | 0.75 | 3.0 |
| Production | 0.25 | 1.0 | 2.5 |
| Use | 0.0 | 0.5 | 0.75 |
| End of life disposal | 2.0 | 0.0 | 0.75 |

Based upon the information given in the tables and using global warming potential of $CH_4$ equal to 23 kg $CO_2$ per kg of $CH_4$, which of the following statement(s) is/are true?

a) Greenhouse gas emissions (kg $CO_2$ equivalent/f.u.) from the 'Material extraction' phase of product P is higher than that of product Q.

b) Greenhouse gas emissions (kg $CO_2$ equivalent/f.u.) from the 'Production' phase of product Q is higher than that of product P.

c) Greenhouse gas emissions (kg $CO_2$ equivalent/f.u.) from the 'End of life disposal' is higher for product Q than that of product P.

d) Greenhouse gas emissions (kg $CO_2$ equivalent/f.u.) from the 'complete life cycle' of the product P is higher than that of product Q.
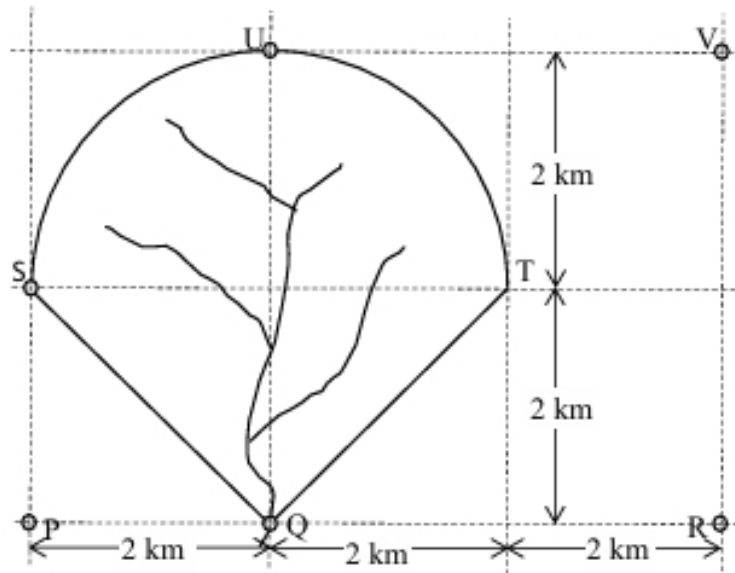
(GATE ES 2023)

47) Second order ordinary differential equation $\frac{d^2y}{dx^2} - \frac{dy}{dx} - 2y = 0$ has values $y = 2$ and $\frac{dy}{dx} = 1$ at $x = 0$. The value of $y$ at $x = 1$ is _____ (rounded off to three decimal places). (GATE ES 2023)

48) Consider two matrices $\mathbf{P} = \begin{bmatrix} 2 & 3 \\ 1 & 4 \end{bmatrix}$ and $\mathbf{Q} = \begin{bmatrix} 5 & 4 \\ 0 & 2 \end{bmatrix}$. If $\mathbf{R} = (\mathbf{PQ})^T$ then $\det \mathbf{R}$ is _____ (in integer). (GATE ES 2023)

49) For the function $f(x) = x\sqrt{4 - x^2}$, the maximum value in the range $-2 \leq x \leq 2$ is _____ (rounded off to two decimal places). (GATE ES 2023)

50) The solubility of gas A is 16 mg/L in water and its vapor pressure is 0.042 atm at 25°C. In a closed system, the gas phase concentration of A is $10^{-3}$ mol/L. Assuming ideal gas constant (R) value as 0.0821 L·atm/mol·K, the concentration of gas A in water at 25°C is _____ (in mg/L, rounded off to two decimal places). (GATE ES 2023)

51) The following figure (not to the scale) shows a catchment (Q, S, U, T, Q) and adjoining rainguage stations P, Q, R, S, U and V. Due to a storm, 20 mm, 25 mm, 30 mm, 15 mm, 22 mm and 18 mm rainfall depths were recorded by raingauges at P, Q, R, S, U and V, respectively.



The corresponding mean rainfall over the catchment using Thiessen polygon method is _____ (in mm, rounded off to two decimal places). (GATE ES 2023)

52) A trapezoidal canal lined with cement concrete ($n = 0.01$) is designed to carry a discharge of 20 m$^3$/s at a bed slope 1 in 400. If the bed width is twice the depth of flow and side slope of the canal section is 2 (1 vertical: 2 horizontal) then the corresponding depth of flow will be _____ (in m, rounded off to two decimal places). (GATE ES 2023)

53) A plunger weighing 314 kN is balanced in a cylindrical vessel of diameter 1.5 m and filled with an oil (specific gravity 0.9) as shown in the following figure (not to the scale).
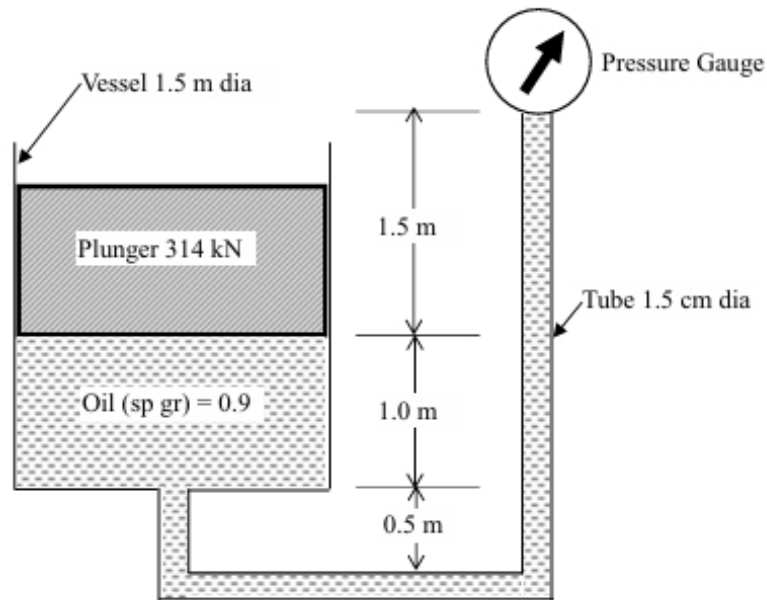


If a pressure gauge is connected with the vessel using 1.5 cm diameter tube, the reading of the gauge will be _____ (in kPa, rounded off to two decimal places).                  (GATE ES 2023)

54) A fully penetrating well is installed in a homogenous and isotropic confined aquifer. The aquifer has uniform thickness of 16 m and hydraulic conductivity of 25 m/d. Water is being pumped out from the well at a constant rate of 0.1 $m^3$/s till steady state condition is reached. If a drawdown of 3.5 m is observed at a distance of 75 m from the well then the drawdown at a distance of 150 m from the well will be _____ ($textinm, roundedoff totwodecimalplaces$).                  (GATE ES 2023)

55) A biological reactor is getting wastewater containing 1 mole/L acetate ions as carbon source. The following reaction takes place in the bio-reactor:

$$0.125CH_3COO^- + 0.0295NH_4^+ + 0.103O_2 \rightarrow 0.0295C_5H_7O_2N + 0.0955H_2O + 0.095HCO_3^- + 0.007CO_2$$

Assume that all acetate ions are consumed and ammonia serves as a nutrient source. Given that 1 g acetate exerts 1.07 g COD; 1 mole bacteria = 113 g VSS; 1 mole acetate ion = 59 g. Value of observed yield is _____ (in g VSS/g COD, *rounded off to two decimal places*).        (GATE ES 2023)

56) A flask (100 mL volume) has wastewater, which has 0.12 mg/L geosmin. Activated carbon is added in this flask for adsorbing geosmin as per the Freundlich isotherm model ($Q = 2.6C^{0.73}$ where $Q$ is mg adsorbate/mg adsorbent and $C$ is the equilibrium concentration in mg/L). Activated carbon to be added in this flask for getting final remaining geosmin concentration of 0.05 mg/L would be _____ (in mg/L, *rounded off to three decimal places*).                (GATE ES 2023)

57) A pipeline is designed to deliver 20 L/s of an oil (kinematic viscosity = $6 \times 10^{-6}$ m$^2$/s and specific gravity = 0.9 under the laminar flow condition. The minimum diameter of the pipe will be _____ (in m, *rounded off to tw* (GATE ES 2023)

58) You are doing an experiment to find out BOD$_5$ of a wastewater. You have taken 25 mL wastewater having ultimate BOD of 75 mg/L and placed it into 300 mL BOD bottle and filled it with dilution water. The initial DO of the diluted sample is 6.5 mg/L. On the 5$^{th}$ day, you were not able to measure the DO due to unavoidable circumstances. However, the DO at the end of the 7$^{th}$ day is found to be 1.25 mg/L. Assume all the experiments are done at the same temperature, and no biodegradable organics are present in the dilution water. The BOD$_5$ of the wastewater sample is _____ (in mg/L, *rounded off to two decimal places*).                (GATE ES 2023)

59) In a 30 m$^3$ room, a stove in operation consumes wood at the rate of 0.25 kg/h. The inflow and outflow rate of air in the room is the same, i.e., 500 m$^3$/h. This stove emits a VOC species at a rate of 0.2 g/kg-wood. The VOC species gets converted to CO$_2$ at a rate of 0.4 per hour. Given: (i) the air in the room is completely mixed, (ii) initial concentration of the VOC species in the room is negligible, and (iii) concentration of the VOC species in the air entering the room is negligible. The concentration of the VOC species due to two hours of stove operation in the room is _____ (in $\mu$g/m$^3$, *rounded off to one decimal place*).                (GATE ES 2023)

60) A city generates on average 1000 metric tonnes/day of municipal solid waste and follows integrated waste management system. 15% of the total waste is recycled, 40% of the total waste is used to produce compost, 25% of the total waste is converted to refuse derived fuel (*RDF*) with 80% efficiency. Remaining is disposed of in a sanitary landfill. The calorific value of the RDF is 15 MJ/kg, which is further used to generate electricity. The electrical energy that could be generated from the RDF with a thermal to electrical energy conversion efficiency of 20% is _____ (in MWh/d, *rounded off to two decimal places*).                (GATE ES 2023)

61) An industry with an effective stack height of 80 m emits 1200 g/h of CO. The windrose plotted using the meteorological data at the top of the stack, and the relation between dispersion coefficients and wind direction are given below:
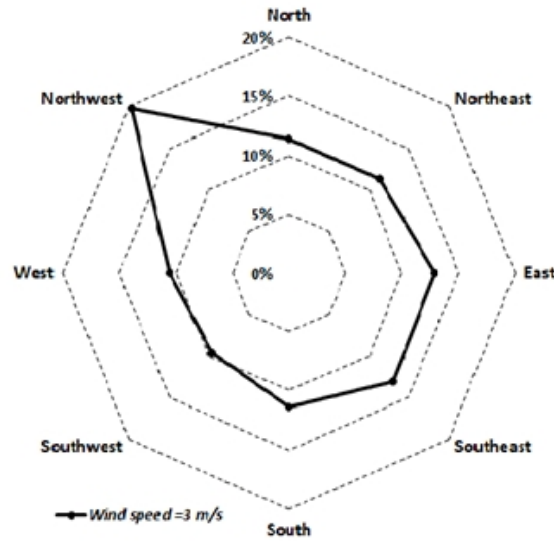


| Wind Direction | Crosswind direction (m) | Vertical direction (m) |
|---|---|---|
| Northeast | 50 | 20 |
| North | 45 | 30 |
| Northwest | 40 | 35 |
| East | 45 | 30 |
| Southeast | 55 | 35 |
| South | 60 | 40 |
| Southwest | 65 | 45 |
| West | 70 | 50 |

During the maximum duration of the year, the ground level PM$_{2.5}$ concentration at the downwind distance of 2 km (at the plume centerline) from the stack is _____ $\left(\text{in } \mu\text{g/m}^3, \textit{rounded off to two decimal pla}\right.$
(GATE ES 2023)

62) Ms. Anita uses a BS-IV two wheeler petrol scooter, with a mileage of 50 km/L, to travel 30 km every day. She exchanges this two wheeler with an electric scooter, which consumes electricity at 0.1 kWh/10 km. Assuming the cost of petrol and electricity are fixed at Rs. 90 per L and Rs. 3.5 per kWh, respectively, and maintenance cost of both BS-IV two wheeler and electric scooter is negligible, the operational cost saved in a year by Ms. Anita is _____ (in Rs., in integer).  (GATE ES 2023)

63) Ultimate analysis of a municipal solid waste sample is given below:

| Percent by weight | |
|---|---|
| Carbon | 48 |
| Hydrogen | 6 |
| Oxygen | 35 |
| Nitrogen | 6 |
| Ash | 5 |

For 1 kg of the municipal solid waste burnt, assuming that air contains only nitrogen and oxygen, maximum $CO_2$ emitted is _____ (in kg, *rounded off to three decimal places*). (GATE ES 2023)

64) An adult of 65 kg weight and life span of 65 years drinks water for 5 years, which is contaminated with toluene of concentration 0.15 mg/L. For toluene, reference dose is 0.200 mg/kg·d. The person drinks 2 L of water per day. The hazard quotient from the toluene exposure for the adult will be _____ brak*rounded off to three decimal places*.                                    (GATE ES 2023)

65) An aeration tank needs to be installed for the removal of VOC from water, where the required rate of flow of water through the aeration tank is 180,000 m$^3$/d. Permissible limit of VOC in the water is 12 $\mu$g/L. The saturation concentration of VOC is 5 $\mu$g/L and gas transfer rate constant is 0.40 per second at 25°C. The initial concentration of VOC in the water is 33 $\mu$g/L. The volume of the aeration tank to satisfy the permissible limit of VOC at 25°C is _____ $\left(\text{in m}^3, \textit{rounded off to two decimal places}\right)$. (GATE ES 2023)

ENDOFQUESTIONPAPER