XE: ENGINEERING SCIENCES

Duration: Three Hours | Maximum Marks: 100

A: ENGINEERING MATHEMATICS (Compulsory)

Q.1 Let A and B be two similar square matrices of order two. If 1 and -2 are the eigenvalues of A, then the Trace of B is [GATE XE 2009]

a) -2 b) -1 c) 1 d) 2

Q.2 The root of $ax + b = 0$ (a, b constants) can be found by the Newton-Raphson method with a minimum of [GATE XE 2009]

a) 1 iteration
b) 2 iteration
c) 3 iteration
d) an undeterminable number of iteration

Q.3 The solution $u(x,t)$ of the one-dimensional heat equation [GATE XE 2009]

$$\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$$

with a Gaussian initial condition

(A) travels with finite constant wave-speed
(B) travels with finite variable wave-speed
(C) spreads in both directions, with the magnitude of the peak increasing with time
(D) spreads in both directions, with the magnitude of the peak decreasing with time

Q.4 Let C be the boundary of the square given by $0 \le x \le 1$, $0 \le y \le 1$. Then[GATE XE 2009]

$$\oint_C (x\,dy - y\,dx)$$

equals

a) -2 b) -1 c) 1 d) 2

Q.5-Q.12 carry 2 marks each

Q.5 Let the eigenvalues of a square matrix A of order two be 1 and 2. The corresponding eigenvectors are of [GATE XE 2009]

$$\begin{pmatrix} 0.6 \\ 0.8 \end{pmatrix} \text{and} \begin{pmatrix} 0.8 \\ -0.6 \end{pmatrix}$$

respectively. Then, the element $A(2,2)$ is

a) -0.48 b) 0.48 c) 1.36 d) 1.64

Q.6 Let $y_1(x)$ and $y_2(x)$ be two linearly independent solutions of [GATE XE 2009]

$$\frac{d^2y}{dx^2} + \frac{6}{x}\frac{dy}{dx} + q(x)y = 0, \quad x \in (1,3)$$

where $q(x)$ is continuous in $(1,3)$. If the Wronskian $W(y_1, y_2)(1) = 1$, then $W(y_1, y_2)(2)$ is

a) $\frac{1}{2^6}$ b) $\frac{1}{2^3}$ c) $\frac{1}{2}$ d) 1

Q.7 Simpson's 1/3 rule applied to $\int_{-1}^{1}(3x^2+5)dx$, with sub-interval $h=1$, will give[GATE XE 2009]

a) the exact result
b) error between 0.01% 0.1%
c) error between 0.1% to 1.0%
d) $error > 1.0\%$

Q.8 The probability that a six-sided dice is thrown n times without giving a '6', even once, is [GATE XE 2009]

a) $\left(\frac{5}{6}\right)^n$
b) $\frac{n!}{(n-1)!}\frac{1}{6^n}$
c) $\frac{n!}{(n-1)!}\frac{5^n}{6^n}$
d) $1-\frac{1}{n!}$

Q.9 If a complex function $f(z)=u(x,y)+iv(x,y)$ is analytic, then [GATE XE 2009]

a) $\frac{\partial u}{\partial x}+i\frac{\partial v}{\partial x}=\frac{\partial u}{\partial y}+i\frac{\partial v}{\partial y}$
b) $\frac{\partial u}{\partial x}+i\frac{\partial v}{\partial x}=-i\frac{\partial u}{\partial y}-\frac{\partial v}{\partial y}$
c) $\frac{\partial u}{\partial x}+i\frac{\partial v}{\partial x}=-i\frac{\partial u}{\partial y}+\frac{\partial v}{\partial y}$
d) $\frac{\partial u}{\partial x}+i\frac{\partial v}{\partial x}=i\frac{\partial u}{\partial y}-\frac{\partial v}{\partial y}$

Q.10 Let $\mathbf{u}=-\omega y\,\hat{i}+\omega x\,\hat{j}$ and $\mathbf{v}=\omega z\,\hat{j}-\omega y\,\hat{k}$ be two given vectors, where ω is a constant. Then $\text{div}(\mathbf{u}\times\mathbf{v})$ equals [GATE XE 2009]

a) 0 b) $2\omega^2 y$ c) $4\omega^2 y$ d) $-4\omega^2 y$

Q.11 The infinite series $\sum_{m=1}^{\infty}\frac{(-1)^m x^2}{(1+x^2)^m}$ is [GATE XE 2009]

(A) Divergent for all x
(B) Convergent only for $x \geq 1$
(C) Convergent for all x
(D) Divergent only for $-1 \leq x \leq 1$

Q.12 Let $f(x)$ be continuous and satisfy $m \leq f(x) \leq M$ in $1 \leq x \leq 10$. Then, [GATE XE 2009]

$$\mu=\frac{\int_1^{10} f(x)x^2dx}{\int_1^{10} x^2dx}$$

a) (A) $\mu \leq 333m$ b) $333\mu \geq M$ c) $m \leq \mu \leq M$ d) $m \leq \mu \leq \frac{333}{M}$

B : FLUID MECHANICS

Useful Data

Acceleration due to gravity, $g = 10$ m/s^2

Density of water, $\rho_w = 1000$ kg/m^3

Density of air, $\rho_a = 1.2$ kg/m^3

Density of mercury (Hg), $\rho_{Hg} = 13600$ kg/m^3

Dynamic viscosity of water, $\mu_w = 10^{-3}$ kg/(m $\cdot$ s)

Dynamic viscosity of air, $\mu_a = 1.8\times10^{-5}$ kg/(m $\cdot$ s)

Q.1 Under what conditions is the equation $A \cdot pV = 0$ valid? [GATE XE 2009]
P: Steady incompressible flow
Q: Unsteady incompressible flow
R: Steady compressible flow
S: Unsteady compressible flow

i) P, Q, R   ii) Q, R, S   iii) P, R, S   iv) P, Q, S

Q.2 Stream function CANNOT be defined for [GATE XE 2009]

i) two dimensional incompressible flow
ii) two dimensional compressible flow
iii) three dimensional incompressible flow
iv) axisymmetric incompressible flow

Q.3 Which one of the following is an irrotational flow? [GATE XE 2009]
(A) Free vortex flow
(B) Forced vortex flow
(C) Couette flow
(D) Wake flow

Q.4 Under strong wind conditions, electrical cables can be subjected to wind-induced oscillations. Which one of the following non-dimensional numbers is relevant to this problem? [GATE XE 2009]

i)
ii) Froude number
iii) Weber number
iv) Faraday number
v) Strouhal number

Q.5 Dimples are made on golf balls for which of the following reasons? [GATE XE 2009]

P : to make the ball travel a longer distance
Q : to make the flow over the ball turbulent
R : to make the flow over the ball laminar
S : to create a separated boundary layer flow over the ball

i) P, Q   ii) Q, S   iii) R, S   iv) P, R

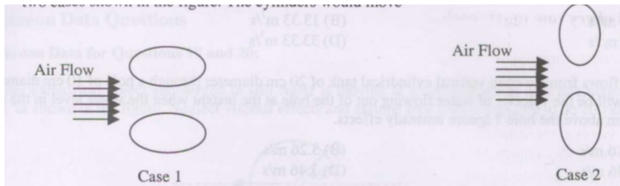
Q.6 In a 2-D boundary layer flow, x and y are the streamwise and wall-normal coordinates, respectively. If u denotes the velocity along the x direction, which one of the following represents the condition at the point of flow separation? [GATE XE 2009]

i) $\frac{\partial u}{\partial y} = 0$ ii) $\frac{\partial u}{\partial x} = 0$ iii) $\frac{\partial^2 u}{\partial y^2} = 0$ iv) $\frac{\partial^2 u}{\partial x^2} = 0$

Q.7 Which one among the following boundary layer flows is the LEAST susceptible to flow separation? [GATE XE 2009]
(A) turbulent boundary layer in a favourable pressure gradient
(B) laminar boundary layer in a favourable pressure gradient
(C) turbulent boundary layer in an adverse pressure gradient

(D) laminar boundary layer in an adverse pressure gradient

Q.8 Air from the blower of a hairdryer flows between two identical elliptical cylinders suspended freely, for two cases shown below. The cylinders would move [GATE XE 2009]



(A) away from each other for Case 1 and towards each other for Case 2
(B) towards each other for Case 1 and away from each other for Case 2
(C) away from each other for Case 1 and away from each other for Case 2
(D) towards each other for Case 1 and towards each other for Case 2

Q.9 A 40 cm cubical block slides on oil (viscosity = 0.80 Pa.s), over a large plane horizontal surface. If the oil film between the block and the surface has a uniform thickness of 0.4 mm, what will be the force required to drag the block at 4 m/s? Ignore the end effects and treat the flow as two dimensional. [GATE XE 2009]

i) 1280 N
ii) 1640 N
iii) 1920 N
iv) 2560 N

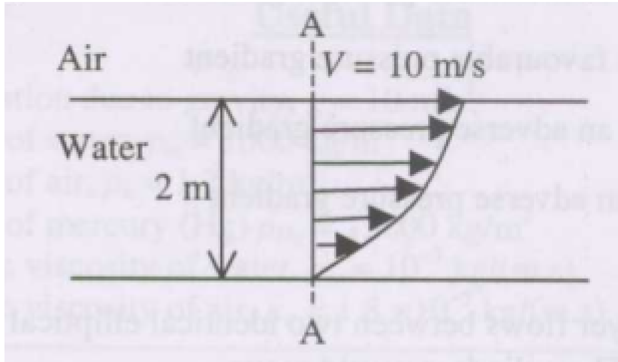
Q.10 For a floating body, G, B, and M represent the centre of gravity, centre of buoyancy, and the metacentre, respectively. The body will be stable if [GATE XE 2009]

i) G is located above B
ii) B is located above M
iii) M is located above B
iv) M is located above G

Q.11 A nozzle has inlet and outlet diameters of 10 cm and 5 cm, respectively. If it discharges air at a steady rate of 0.1 m^3/s into the atmosphere, the gauge pressure (static) at the nozzle inlet will be [GATE XE 2009]

i) 1.26 kPa
ii) 1.46 kPa
iii) 3.52 kPa
iv) 3.92 kPa

Q.12 Consider incompressible flow through a two-dimensional open channel. At a certain section A-A, the velocity profile is parabolic. Neglecting air resistance at the free surface, find the volume flow rate per unit width of the channel. [GATE XE 2009]

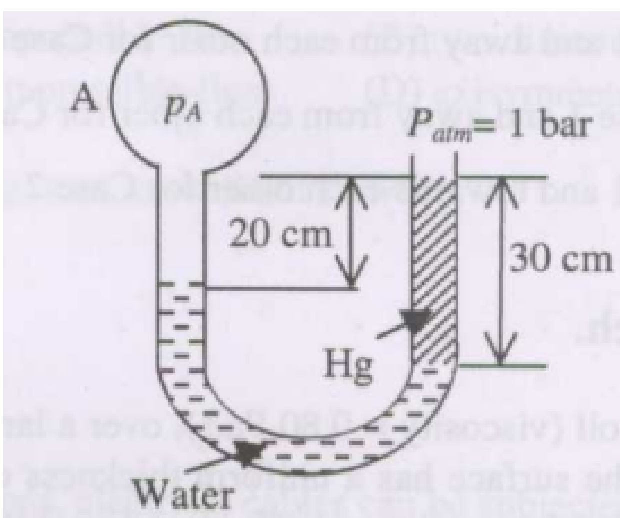


i) 10 m^3/s
ii) 13.33 m^3/s
iii) 20 m^3/s
iv) 33.33 m^3/s

Q.13 Water flows from an open vertical cylindrical tank of 20 cm diameter through a hole of 10 cm diameter. What will be the velocity of water flowing out of the hole at the instant when the water level in the tank is 50 cm above the hole? Ignore unsteady effects.[GATE XE 2009]

i) 3.16 m/s
ii) 3.26 m/s
iii) 3.36 m/s
iv) 3.46 m/s

Q.14 In the manometer shown in the figure, the pressure p_A of the gas inside bulb A is approximately. [GATE XE 2009]



i) 0.8 bar
ii) 1.2 bar
iii) 1.4 bar
iv) 1.6 bar

Q.15 Consider a fully developed laminar flow in a circular pipe. If the diameter of the pipe is halved while the flow rate and length of the pipe are kept constant, the head loss increases by a factor of [GATE XE 2009]

i) 4
ii) 8
iii) 16
iv) 32

Q.16 A 1:20 model of a submarine is to be tested in a towing tank containing sea water. If the submarine velocity is 6 m/s, at what velocity should the model be towed for dynamic similarity? [GATE XE 2009]

i) 60 m/s
ii) 120 m/s
iii) 180 m/s
iv) 240 m/s

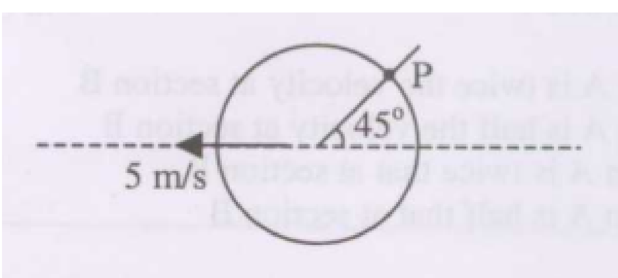
Q.17 An oil droplet (density = 800 kg/m^3) is rising in still water at a constant velocity of 1 mm/s. Its radius is approximately [GATE XE 2009]

i) 21 micron
ii) 24 micron
iii) 34 micron
iv) 47 micron

Q.18 Determine the correctness or otherwise of the following Assertion [a] and the Reason [r]: [GATE XE 2009]
Assertion [a]: The coefficient of discharge of orifice flow meter is less than that of venturi meter.
Reason [r]: Orifice flow meter is a differential pressure device.

i) Both [a] and [r] are true and [r] is the correct reason for [a].
ii) Both [a] and [r] are true but [r] is not thea correct reason for [a].
iii) Both [a] and [r] are false.
is true but [r] is false.

Common Data for Questions 19 and 20:
A long cylindrical object submerged in still water is moving at a constant speed of 5 m/s perpendicular to its axis, as shown in the figure. Neglect viscous effects and assume free stream pressure to be 100 kPa.



Q.19 The fluid velocity at point P with respect to the cylinder will be approximately [GATE XE 2009]

i) 3.5 m/s
ii) 5 m/s
iii) 7 m/s
iv) 10 m/s

Q.20 The absolute pressure at point P will be approximately [GATE XE 2009]

i) 137 kPa
ii) 112 kPa
iii) 87 kPa
iv) 62 kPa

Common Data for Questions 21 and 22:
The velocity field for a two dimensional flow is given by:

$$\mathbf{V}(x, y, t) = -\frac{2x}{t^2}\hat{i} + \frac{y}{t}\hat{j}$$

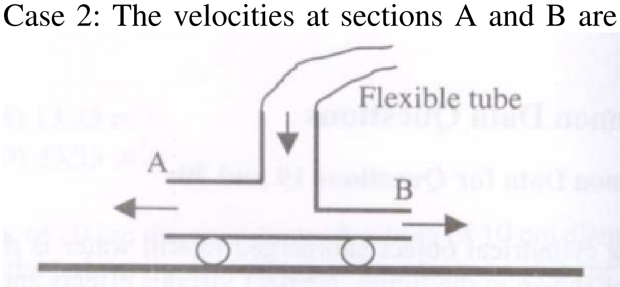
Q.21 The total acceleration is [GATE XE 2009]

i) $-\frac{2x}{t^2}\hat{i}$
ii) $\frac{y}{t^2}\hat{j}$
iii) $-\frac{2x}{t^3}\hat{i}$
iv) $-\frac{y}{t}\hat{j}$

Q.22 The given velocity field is [GATE XE 2009]

i) incompressible and rotational
ii) compressible and rotational
iii) incompressible and irrotational
iv) compressible and irrotational

Linked Answer Questions:
Statement for Linked Answer Questions 23 and 24:
An incompressible fluid is passed through a T-junction supported on wheels, as shown in the figure. The area at outlet A is twice that of outlet B. While the incoming mass flow rate is fixed, the distribution of flow at the two outlets can be varied by a suitable mechanism built in the system. Assume that the flexible tube offers no resistance to motion, and frictional effects in the pipes and wheels can be neglected. Now, consider the following two cases:
Case 1: The flow rates at sections A and B are equal.
Case 2: The velocities at sections A and B are equal.



Q.23 Which of the following statements are true? [GATE XE 2009]
P: In Case 1, the velocity at section A is twice the velocity at section B.
Q: In Case 1, the velocity at section A is half the velocity at section B.
R: In Case 2, the flow rate at section A is twice that at section B.
S: In Case 2, the flow rate at section A is half that at section B.

i) P, R
ii) P, S
iii) Q, R
iv) Q, S

Q.24 Which of the following statements are true? [GATE XE 2009]
P: In Case 1, the system moves to the left.
Q: In Case 1, the system moves to the right.
R: In Case 2, the system moves to the left.
S: In Case 2, the system moves to the right.

i) P, R
ii) P, S
iii) Q, R
iv) Q, S

C : MATERIALS SCIENCE

Useful data

Avogadro's Number	: 6.023×10^{23} mol^{-1}
Boltzmann's constant	: 1.38×10^{-23} J K^{-1}
Electron Charge	: 1.6×10^{-19} C
Gas Constant	: 8.314 J mol^{-1} K^{-1}
Electron rest mass	: 9.1×10^{-31} kg
Permittivity of vacuum (ε_0)	: 8.854×10^{-12} F m^{-1}
Planck's constant (h)	: 6.62×10^{-34} J s^{-1}
Bohr Magneton (μ_B)	: 9.27×10^{-24} A m^2

1 eV = 1.6×10^{-19} J
1 cal = 4.2 J

Atomic weight (in kg mol^{-1}) of:

Hydrogen	0.001
Carbon	0.012
Nitrogen	0.014

Q.1-Q.8 carry one mark each

Q.1 Equal size spherical balls when packed together will yield maximum theoretical packing of [GATE XE 2009]

i) 52%
ii) 68%
iii) 74%
iv) 86%

Q.2 Steel containing 0.8% carbon cooled under equilibrium conditions from molten state to room temperature is soft, because it consists of lamellae of [GATE XE 2009]

i) Ferrite and cementite
ii) Ferrite and austenite
iii) Ferrite and bainite
iv) Ferrite and martensite

Q.3 Line broadening in X-ray diffraction pattern occurs on account of [GATE XE 2009]

i) Coarse crystallite size
ii) Residual stresses
iii) Multiplicity of phases
iv) Coring of crystallites

Q.4 Inter-granular corrosion of austenitic stainless steel is promoted by [GATE XE 2009]

i) Fine grained microstructure
ii) Coarse grained microstructure
iii) Soaking steel at 700°C in air
iv) Quenching from 1000°C

Q.5 Ferrites are preferred materials for use in high frequency applications (GHz range) as opposed to other ferromagnetic materials because ferrites also have [GATE XE 2009]

i) High permeability
ii) High electrical resistivity
iii) High saturation magnetisation
iv) Low coercivity

Q.6 During indirect intra-band transition, electrons undergo [GATE XE 2009]

i) Change in energy and momentum
ii) Change in momentum but no change in energy
iii) Change neither in energy nor in momentum
iv) Change in energy but no change in momentum

Q.7 A material has a band gap of 2.4 eV. Which of the following wavelengths of light will it absorb? [GATE XE 2009]

i) 700 nm
ii) 550 nm
iii) 650 nm
iv) 400 nm

Q.8 Thermal conductivity of a material at a temperature greater than Debye temperature [GATE XE 2009]

i) Is independent of temperature
ii) Decreases inversely with temperature
iii) Increases linearly with temperature
iv) Increases exponentially with temperature

Q.9 Match the following classes of materials given in Column I with the electron spin alignments in atoms shown in Column II. [GATE XE 2009]

Match the roles shown in Column I with those shown in Column II.

Column I	**Column II**
P. Ferromagnetic	1. ↑↓↑↓
Q. Anti-ferromagnetic	2. →↗↘↙↙←
R. Ferrimagnetic	3. ↑↑↑↑
S. Paramagnetic	4. ↓↓↓↓
	5. ↑↑↑

i) P-3, Q-1, R-4, S-5
ii) P-4, Q-2, R-5, S-3
iii) P-3, Q-1, R-5, S-2
iv) P-3, Q-2, R-4, S-1

Q.10 Match the following **experimental techniques** given in Column I with applications given in Column II. [GATE XE 2009]

Column I	Column II
P. Differential Scanning Calorimetry	1. Dislocation studies
Q. Atomic Absorption Spectroscopy	2. Surface Topography
R. Scanning Electron Microscopy	3. Electrical Conductivity
S. Transmission Electron Microscopy	4. Trace Element Analysis
	5. Phase Transformation

(A) P-5, Q-4, R-2, S-1 (B) P-5, Q-1, R-3, S-2
(C) P-2, Q-5, R-3, S-1 (D) P-1, Q-5, R-4, S-2

Q.11 Match the following materials given in Column I with their applications given in Column II. [GATE XE 2009]

Column I	Column II
P. Nylon	1. Electrical switch housing
Q. Urea formaldehyde	2. Conducting polymers
R. Polyaniline	3. Heating Element
S. Alumina	4. Gears for toys
	5. Polishing material

(A) P-2, Q-4, R-3, S-5 (B) P-4, Q-1, R-2, S-5
(C) P-3, Q-4, R-2, S-1 (D) P-4, Q-5, R-3, S-2

Q.12 Match the following materials given in Column I with their applications given in Column II. [GATE XE 2009]

Column I	Column II
P. Silicon carbide fibre	1. Fibre glass boat
Q. Polyester fibre	2. Heating element
R. Thoria doped tungsten	3. Magnetic material
S. Nichrome	4. Electric bulb filament
	5. Armour material

(A) P-5, Q-1, R-3, S-2 (B) P-1, Q-5, R-4, S-2
(C) P-5, Q-3, R-2, S-1 (D) P-5, Q-1, R-4, S-2

Q.13 Correlate the material properties given in Column I with the units given in Column II. [GATE XE 2009]

Column I	Column II
P. Magnetic moment	1. $MN^{-\frac{3}{2}}$
Q. Thermal conductivity	2. $H\ m^{-1}$
R. Fracture toughness	3. $A\ m^2$
S. Electron mobility	4. $m^2\ V^{-1}\ s^{-1}$
	5. $J\ s^{-1}\ m^{-1}\ K^{-1}$

(A) P-2, Q-5, R-1, S-4 (B) P-4, Q-5, R-1, S-3
(C) P-3, Q-5, R-1, S-4 (D) P-3, Q-2, R-4, S-1

Q.14 A simply supported beam with an overhanging end is loaded as shown below. The maximum bending moment in the beam is [GATE XE 2009]

i) 2 kN m
ii) 1 kN m
iii) 0.75 kN m
iv) 0.25 kN m

Q.15 A body P while moving rectilinearly with velocity v_0 collides directly with another body Q, which is at rest, as shown below. Assuming both the bodies have the same mass and the collision is elastic, the velocities of the bodies after the collision, measured positive towards right, are [GATE XE 2009]

i) $v_p = -\frac{v_0}{2},\ v = \frac{v_0}{2}$
ii) $v_p = \frac{v_0}{2},\ v = \frac{v_0}{2}$
iii) $v_p = 0,\ v = \frac{v_0}{2}$
iv) $v_p = 0,\ v = v_0$

Q.16 A stepped circular shaft, fixed at one end, is subjected to two axial forces as shown below. The maximum tensile stress in the shaft is [GATE XE 2009]

i) 120 MPa
ii) 210 MPa
iii) 153 MPa
iv) 390 MPa

Q.17 A thin string of negligible mass with one end fixed to the roof is wound around a circular disc of radius 2 m and mass 10 kg, as shown below. The disc rolls vertically down under the action of its own weight. Considering acceleration due to gravity as 10 m/s^2, the tension in the string is [GATE XE 2009]

i) 0 N
ii) 25.0 N
iii) 33.3 N
iv) 50 N

Q.18 Molecular weight distribution of a polystyrene polymer and the number fraction of polymer chains in the molecular weight range are given below. [GATE XE 2009]

Range of Molecular weight (kg/mol)	**Number fraction of polymer chain**
5 – 10	0.05
10 – 15	0.15
15 – 20	0.20
20 – 25	0.30
25 – 30	0.20
30 – 35	0.08
35 – 40	0.02

The number average molecular weight and the number average degree of polymerization will be
(A) 15.750 kg/mol and 151
(B) 21.350 kg/mol and 203
(C) 15.750 kg/mol and 302
(D) 21.350 kg/mol and 205

Common Data

Common Data for Question 19 and 20

Q.19 The change in the thickness of the plate is [GATE XE 2009]

i) 2.39
ii) 5.25
iii) 7.12
iv) 9.16

Q.20 The change in the surface area of the plate is [GATE XE 2009]

i) 9.72 mm^2
ii) 13.61 mm^2
iii) 17.52 mm^2
iv) 24.50 mm^2

Common Data for Question 21 and 22

Q.21 The maximum shear stress due to torsion in the length PQ is [GATE XE 2009]

i) 15.75 MPa
ii) 21.22 MPa
iii) 30.56 MPa
iv) 51.21 MPa

Q.22 The rotation of the free end S due to the torsion is [GATE XE 2009]

i) 0.25°
ii) 0.58°
iii) 1.22°
iv) 1.25°

Common Data for Question 23 and 24

Q.23 The maximum compression of the spring is [GATE XE 2009] [GATE XE 2009]

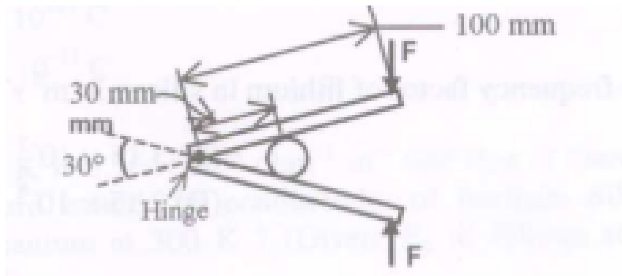
i) 2 mm
ii) 20.2 mm
iii) 202.0 mm
iv) 2020 mm

Q.24 In the ensuing Simple Harmonic Motion of the body, the magnitude of maximum acceleration is [GATE XE 2009]

i) 100 m/s^2
ii) 200 m/s^2
iii) 500 m/s^2
iv) 1000 m/s^2

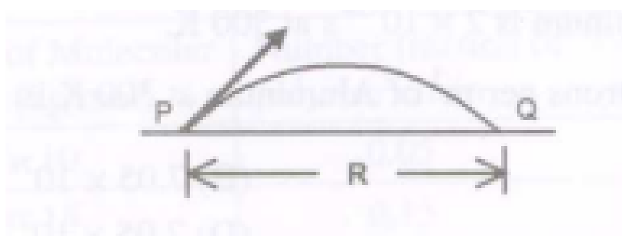
Q.1 – Q.8 carry one mark each.

Q.1 A small spherical ball fails at a normal load of 10 kN under the arrangement as shown below. The vertical force F required to crush the ball is [GATE XE 2009]



(A) 11.6 kN (B) 6.0 kN (C) 3.5 kN (D) 3.1 kN

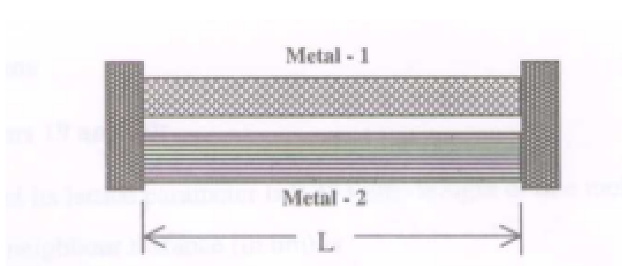
Q.2 A projectile is fired from point P at an angle of 45° with horizontal as shown below. If g is acceleration due to gravity, then the speed required to reach a point Q lying on the horizontal surface at a distance of R from point P is [GATE XE 2009]



(A) $\sqrt{Rg/2}$ (B) $\sqrt{Rg}$ (C) $\sqrt{2Rg}$ (D) $\sqrt{3Rg}$

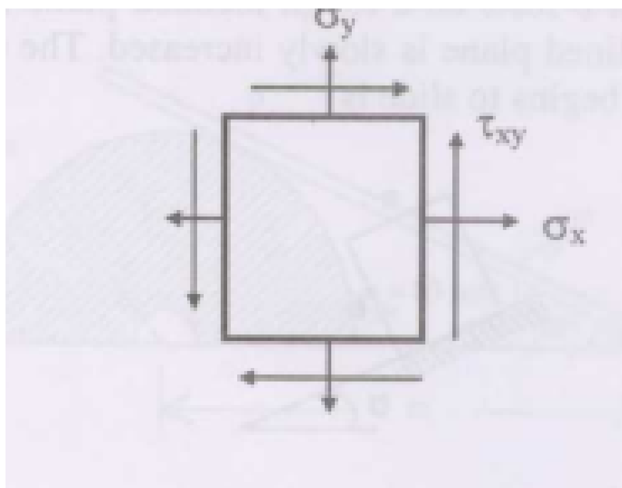
Q.3 The state of stress at a point in a loaded body is given as $\sigma_x = +40$ MPa, $\sigma_y = +60$ MPa, $\tau_{xy} = +10$ MPa. The sum of the principal stresses at that point is[GATE XE 2009]
(A)+20 MPa (B)+50 MPa (C)+100 MPa (D) +110 MPa

Q.4 A composite system of two metal bars, as shown below, is made of two dissimilar materials having areas of cross section A_1 and A_2, Young's moduli E_1 and E_2 and coefficients of thermal expansion α_1 and α_2. If the temperature of the system is raised by ΔT, then the resultant axial force required to be applied to the rigid end plates to maintain the same length L is [GATE XE 2009]



(A) $(E_1\alpha_1A_1 + E_2\alpha_2A_2)\Delta T$
(B) $\left(\frac{1}{E_1A_1} + \frac{1}{E_2A_2}\right)^{-1}\Delta T$
(C) $(E_1 + E_2)(\alpha_1 + \alpha_2)(A_1 + A_2)\Delta T$
(D) $(E_1A_1 + E_2A_2)\Delta T$

Q.5 The state of stress at a point is as shown below. Both the normal and shear stresses on a plane, inclined at an angle of 45° with horizontal are zero. If $\sigma_x = \sigma_y = 200$ MPa, the shear stress T_{xy} is [GATE XE 2009]



i) 50 MPa
ii) 70 MPa
iii) 100 MPa
iv) 200 MPa

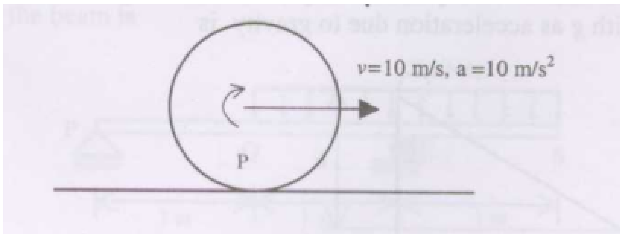
Q.6 A simply supported beam of span L and flexural rigidity EI carries a uniformly distributed load w per unit length. The deflection at the mid-span of the beam is [GATE XE 2009]

i) $\frac{wL^4}{48EI}$
ii) $\frac{5wL^4}{384EI}$
iii) $\frac{5wL^4}{96EI}$
iv) $\frac{3wL^4}{16EI}$

Q.7 During plastic impact of two bodies, which of the following statements is correct?[GATE XE 2009]

i) Both energy and momentum are conserved
ii) Energy is not conserved; momentum is conserved
iii) Energy is conserved; momentum is not conserved
iv) Neither energy nor momentum is conserved

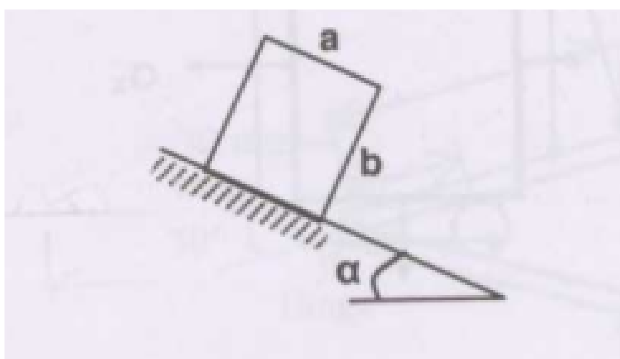
Q.8 A disc of radius 1 m is rolling on the ground without slip. At a certain instant the center of the disc is moving with a velocity of 10 m/s and an acceleration of $a = +10$ m/s^2. The magnitude of acceleration of point P on the disc instantaneously touching the ground is [GATE XE 2009]



i) $0.0\ m/s^2$
ii) $10.0\ m/s^2$
iii) $20.0\ m/s^2$
iv) $100.0\ m/s^2$

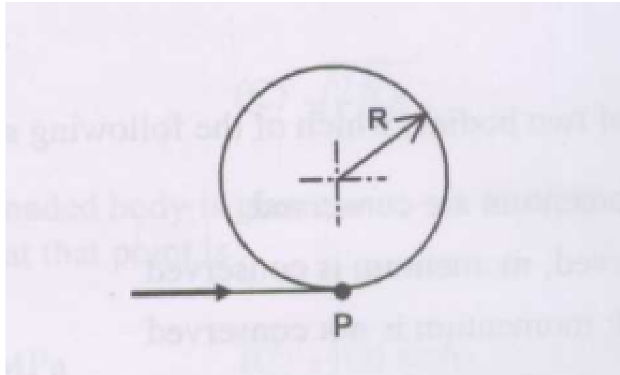
Q.9 to Q.24 carry 2 marks each

Q.9 A block of length a and height b rests on a rough inclined plane (coefficient of friction μ). The angle α of the inclined plane is slowly increased. The condition that the block will topple due to its own weight before it begins to slide is [GATE XE 2009]



i) $\alpha < \mu\frac{b}{a}$
ii) $\alpha > \mu\frac{b}{a}$
iii) $\alpha > \sqrt{1-\mu^2}\frac{b}{a}$
iv) $\alpha < \sqrt{1-\mu^2}\frac{b}{a}$

Q.10 A particle enters a smooth frictionless circular loop of radius R at point P. If g is acceleration due to gravity, the minimum speed required to complete one full circular revolution is [GATE XE 2009]



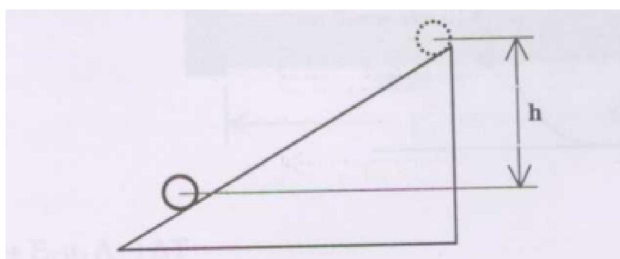
i) $\sqrt{5Rg}$

ii) $\sqrt{3Rg}$

iii) $\sqrt{2Rg}$

iv) ∞

Q.11 A circular cylinder of radius r and mass m, starting from the top of an inclined plane, rolls down without slip. After its center moves to a point with vertical height h, the velocity of the center of mass is (using g for gravity) [GATE XE 2009]



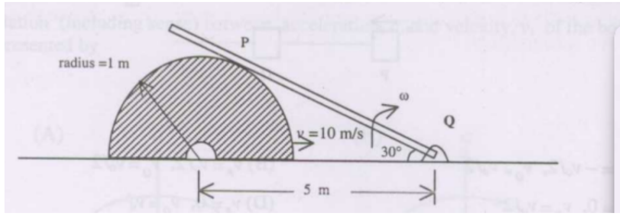
i) $\sqrt{3gh}$

ii) $\sqrt{2gh}$

iii) $\sqrt{\frac{4gh}{3}}$

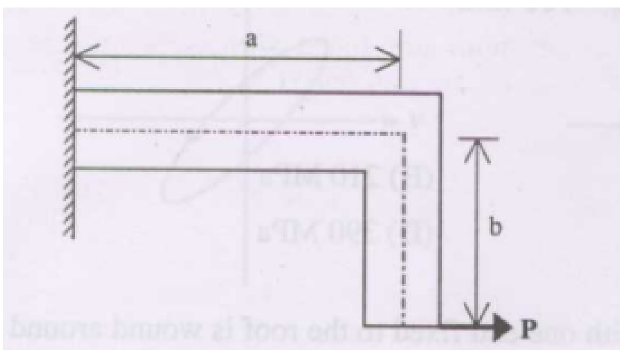
iv) $\sqrt{\frac{3gh}{16}}$

Q.12 Rod PQ, hinged at Q, touches a semicircular cylinder at point P. If the cylinder moves with a constant velocity of 10 m/s horizontally, the angular velocity ω of rod PQ is [GATE XE 2009]



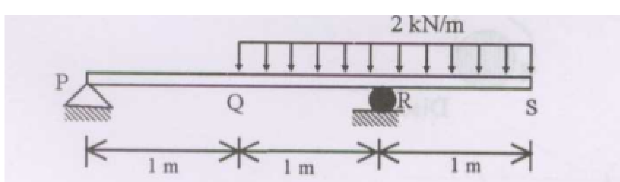
i) 0.5 rad/s
ii) 1.15 rad/s
iii) 2.0 rad/s
iv) 2.3 rad/s

Q.13 An L-shaped elastic member with flexural rigidity EI is loaded as shown below: Total strain energy in the member due to bending is: [GATE XE 2009]



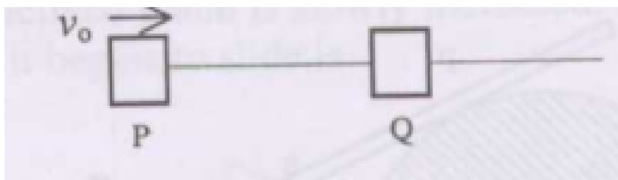
i) $\frac{P^2b^2(b/3+a)}{2EI}$
ii) $\frac{P^2b^2(a/3+b)}{2EI}$
iii) $\frac{P^2a^2(b/3+a)}{3EI}$
iv) $\frac{P^2a^2(a/3+b)}{3EI}$

Q.14 A simply supported beam with an overhanging end is loaded as shown. The maximum bending moment in the beam is: [GATE XE 2009]



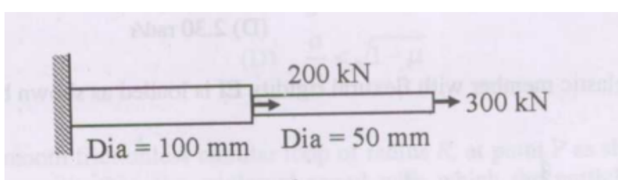
i) 2 kNÂ·m
iii) 0.75 kNÂ·m
ii) 1 kNÂ·m
iv) 0.25 kNÂ·m

Q.15 A body P moving rectilinearly with velocity v_0 collides elastically with a stationary body Q, both having the same mass. The velocities after collision (positive to the right) are: [GATE XE 2009]



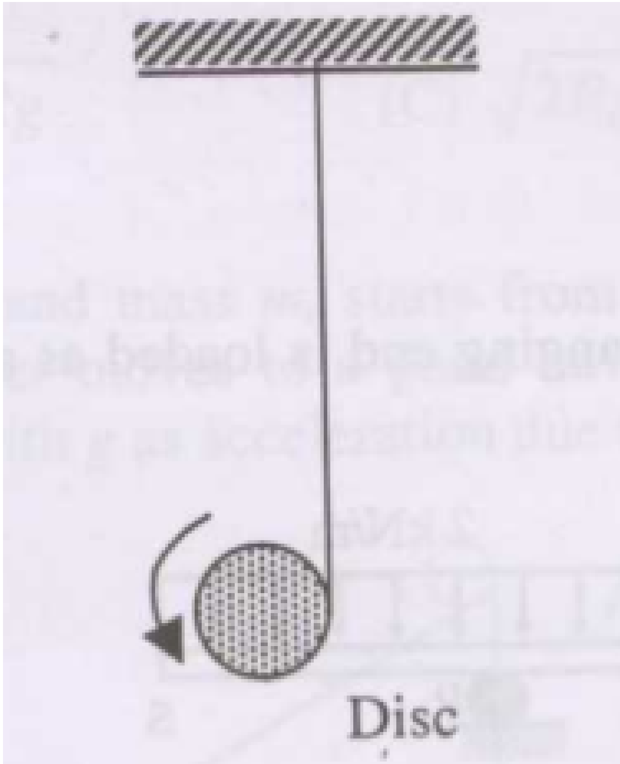
i) $v_P = -\frac{v_0}{2}, v_Q = \frac{v_0}{2}$
iii) $v_P = 0, v_Q = \frac{v_0}{2}$
ii) $v_P = \frac{v_0}{2}, v_Q = \frac{v_0}{2}$
iv) $v_P = 0, v_Q = v_0$

Q.16 A stepped circular shaft fixed at one end is subjected to two axial forces as shown. The maximum tensile stress in the shaft is: [GATE XE 2009]



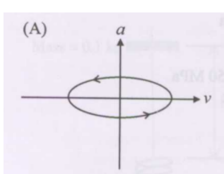
i) 120 MPa
iii) 153 MPa
ii) 210 MPa
iv) 390 MPa

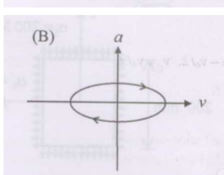
Q.17 A thin string fixed to the roof is wound around a disc of radius 2 m and mass 10 kg, which rolls vertically down under gravity $g = 10\,\mathrm{m/s^2}$. The tension in the string is: [GATE XE 2009]

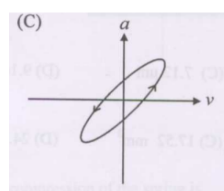


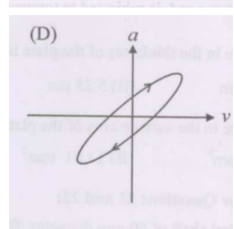
i) 0 N
ii) 25.0 N
iii) 33.3 N
iv) 50 N

Q.18 A spring-mass system executes simple harmonic motion in vertical direction: $\frac{d^2y}{dt^2} + \omega^2 y = 0$. The correct relation between acceleration a and velocity v (including direction) is:[GATE XE 2009]

i) 

ii) 

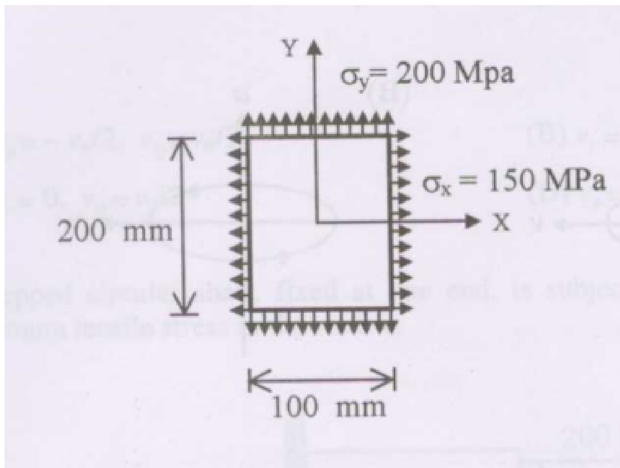
iii) 

iv) 

Common Data Questions

(Common Data for Q.19 and Q.20)

A 10 mm thick steel rectangular plate of size 100 mm × 200 mm is subjected to biaxial stresses of σ_x = 150 MPa, σ_y = 200 MPa, shown below. The Young's modulus and Poisson's ratio are 200 GPa and 0.3 respectively.



Q.19 The change in the thickness of the plate is [GATE XE 2009]

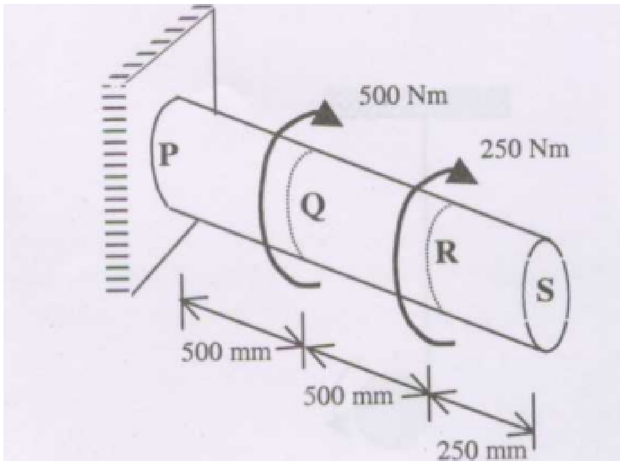
A) 2.39 μm
B) 5.25 μm
C) 7.12 μm
D) 9.16 μm

Q.20 The change in the surface area of the plate is [GATE XE 2009]

A) 9.72 mm^2
B) 13.61 mm^2
C) 17.52 mm^2
D) 24.50 mm^2

(Common Data for Q.21 and Q.22)

A solid circular steel shaft of 50 mm diameter, fixed at one end, is subjected to torques as shown below. The shearing modulus of the material is 80 GPa.



Q.21 The maximum shear stress due to torsion in the length PQ is [GATE XE 2009]

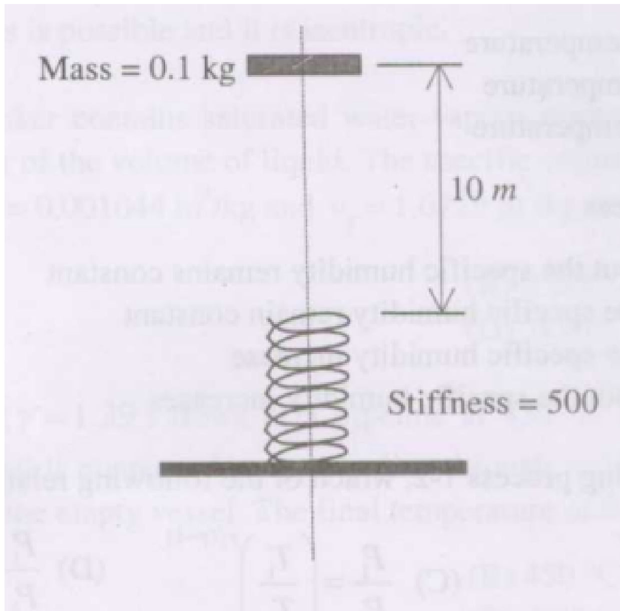
A) 15.75 MPa
B) 21.22 MPa
C) 30.56 MPa
D) 51.21 MPa

Q.22 The rotation of the free end S due to the torsion is [GATE XE 2009]

A) 0.25°
B) 0.58°
C) 1.22°
D) 1.25°

Linked Answer Questions
(Statement for Linked Answer Questions Q.23 and Q.24)

A body of mass 0.1 kg is dropped from a height of 10 m above a spring of stiffness 500 N/m as shown below. The spring is initially in uncompressed natural state. The impact is without any energy loss and the body gets attached to the spring. The acceleration due to gravity is 10 m/s^2.



Q.23 The maximum compression of the spring is[GATE XE 2009]

A) 2 mm
B) 20.2 mm
C) 202.0 mm
D) 2020 mm

Q.24 In the ensuing Simple Harmonic Motion of the body, the magnitude of maximum acceleration is [GATE XE 2009]

A) 100 m/s^2
B) 200 m/s^2
C) 500 m/s^2
D) 1000 m/s^2

E: THERMODYNAMICS

Q.1-Q.2 carry one marks each

Q.1 The ideal gas law is valid for [GATE XE 2009]

A) inert gases
B) gases at high pressure and high temperature
C) gases at low pressure and low temperature
D) gases at low pressure and high temperature

Q.2 During the adiabatic saturation process [GATE XE 2009]

A) the relative humidity increases but the specific humidity remains constant
B) both the relative humidity and the specific humidity remain constant
C) both the relative humidity and the specific humidity increase
D) the relative humidity decreases but the specific humidity increases

Q.3 For an ideal gas undergoing a throttling process 1–2, which of the following relationships holds? [GATE XE 2009]

A) $T_1 = T_2$
B) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$
C) $\frac{P_1}{T_1} = \frac{P_2}{T_2^{\gamma/(\gamma-1)}}$
D) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Q.4 A Carnot refrigerator operating between -1° C and 33° C has a cooling capacity of 1.6 kW. The power consumed by the refrigerator is [GATE XE 2009]

A) 160 W
B) 178 W
C) 200 W
D) 1.8 kW

Q.5 An ideal gas undergoes expansion according to the process $PV^{0.5}$ = constant. The temperature of the gas during the expansion process [GATE XE 2009]

A) does not change
B) increases
C) decreases
D) changes depending on the initial condition

Q.6 Air ($\gamma = 1.4$) is compressed ideally from an initial state of 1 bar and 300 K to a final temperature of 600 K. The value of the final pressure in bar is [GATE XE 2009]

A) 2
B) 3.7
C) 7.2
D) 11.3

Q.7 On a T-s diagram, the slope of the constant volume line for an ideal gas is [GATE XE 2009]

A) less than that of constant pressure line
B) more than that of constant pressure line
C) less than that of constant enthalpy line
D) equal to that of constant enthalpy line

Q.8 The thermal efficiency of an ideal Rankine cycle is less than that of a Carnot cycle operating between the same maximum and minimum temperature limits, because [GATE XE 2009]

A) heat addition does not take place at constant temperature
B) the expansion process is not reversible and adiabatic
C) heat rejection does not take place at constant temperature
D) the compression process is not reversible and adiabatic

Q.9-Q.24 carry two marks each

Q.9 Atmospheric air (R = 287 J/kg; γ = 1.4) at 1 bar and 25 Â°C is compressed adiabatically to 2 bar and 105 Â°C. Which of the following statements is correct? [GATE XE 2009]

A) The process is possible but irreversible.
B) The process is possible and reversible.
C) The process is impossible.
D) The process is possible and it is isentropic.

Q.10 A pressure cooker contains saturated water-vapour mixture at 100 Â°C with vapour volume eight times that of liquid. Given specific volumes of saturated liquid and vapour at 100 Â°C as $v_f = 0.001044\, m^3/kg$ and $v_g = 1.6729\, m^3/kg$ respectively, the quality of the mixture is [GATE XE 2009]

A) 0.005
B) 0.125
C) 0.889
D) 0.995

Q.11 An ideal gas (γ = 1.39) flows in a pipeline at 450 Â°C and 20 bar. A rigid, insulated and initially evacuated vessel is connected to the pipeline through a valve. The valve is opened and the gas fills the vessel. The final temperature of the gas in the vessel is [GATE XE 2009]

A) 247 Â°C
B) 450 Â°C
C) 625 Â°C
D) 732 Â°C

Q.12 An equi-molar mixture of nitrogen (γ = 1.4) and helium (γ = 1.67) initially at 5 bar and 300 Â°C is expanded adiabatically to 2 bar. The final temperature of the mixture is [GATE XE 2009]

A) 149 Â°C
B) 200 Â°C
C) 250 Â°C
D) 524 Â°C

Q.13 A heat engine E_1 operates between an infinite reservoir at 800 Â°C and a body B. The temperature of B remains constant at 550 Â°C. Heat transferred to the engine E_1 is 900 kJ with work output 200 kJ. Another engine E_2 operates between B and the atmosphere at 27 Â°C. Heat rejected to atmosphere is 350 kJ. The thermal efficiency of engine E_2 is [GATE XE 2009]

A) 0.39
B) 0.5
C) 0.61
D) 0.635

Q.14 A gas turbine power plant operates with air ($\gamma = 1.4$) between 1 bar and 20 bar. The maximum thermal efficiency (in %) for the corresponding air-standard cycle is [GATE XE 2009]

A) 30
B) 36.7
C) 48.2
D) 57.5

Q.15 The saturation pressures of water at 100 Â°C and 105 Â°C are 101.3 kPa and 120.8 kPa respectively. Given molecular weight of water = 18, the latent heat of water in kJ/kg at 102.5 Â°C is approximately [GATE XE 2009]

A) 2290
B) 1250
C) 820
D) 330

Q.16 An engine reversibly receives 1200 J of heat at 900 K and rejects heat to ambient at 300 K, developing 600 J of work. The irreversibility (in Joules) is [GATE XE 2009]

A) 600
B) 400
C) 200
D) zero

Q.17 Saturated liquid water at 0.4 MPa and 1000 kg/hr of steam at 0.4 MPa and 300 Â°C enter steadily into an insulated mixing chamber. At 0.4 MPa, enthalpies of saturated liquid and saturated vapour are 604.73 and 2738.53 kJ/kg respectively; enthalpy of superheated steam at 300 Â°C is 3066.75 kJ/kg. The quality of the water-vapour mixture exiting the chamber is 0.9. The mass flow rate of saturated liquid water (kg/hr) is [GATE XE 2009]

A) 182 C) 382
B) 282 D) 1000

Q.18 A gas undergoes the polytropic process $PV^{1.3}$ = constant, from initial state 1.5 MPa and 0.09

A) -217 C) 200
B) -200 D) 217

COMMON DATA QUESTIONS

Common Data for Questions 19 and 20:
Saturated water vapour enters an adiabatic turbine at 0.8 MPa and leaves at 0.1 MPa. The mass flow rate of water vapour is 25 kg/s. Use the following data table to answer the questions 19 and 20.

Pressure (MPa)	**Temperature (°C)**	**Specific enthalpy**		**Specific entropy**	
		h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kg K)	s_g (kJ/kg K)
0.8	170.43	722.11	2769.10	2.0462	6.6628
0.1	99.63	417.46	2675.50	1.3026	7.3594

Q.19 The steam quality at turbine exit after isentropic expansion is [GATE XE 2009]

A) 0.47 C) 0.88
B) 0.72 D) 0.94

Q.20 If the steam leaves the turbine as saturated vapor, the power produced by the turbine (kW) is [GATE XE 2009]

A) 1640
B) 2030
C) 2340
D) 8830

Common Data for Question 21 and 22

thev flow rate of Refrigerant R-12 flow rate is 0.03 kg/s. Entering compressor saturated vapor at 150.9 kPa. After adiabatic compression, superheated vapor at 500 kPa and 100 Â°C enters condenser. Leaves condenser saturated liquid at same pressure.Use the following table to answer the Question 21 and 22.

Pressure (kPa)	Temperature (°C)	Specific enthalpy	
		h_f (kJ/kg)	h_g (kJ/kg)
150.9	−20	17.82	178.74
500	15.6	50.64	195.01

For the superheated vapour at 500 kPa and 100°C, $h = 252.05$ kJ/kg.

Q.21 The refrigeration effect in kW is [GATE XE 2009]

A) 1.71
B) 3.84
C) 4.33
D) 4.83

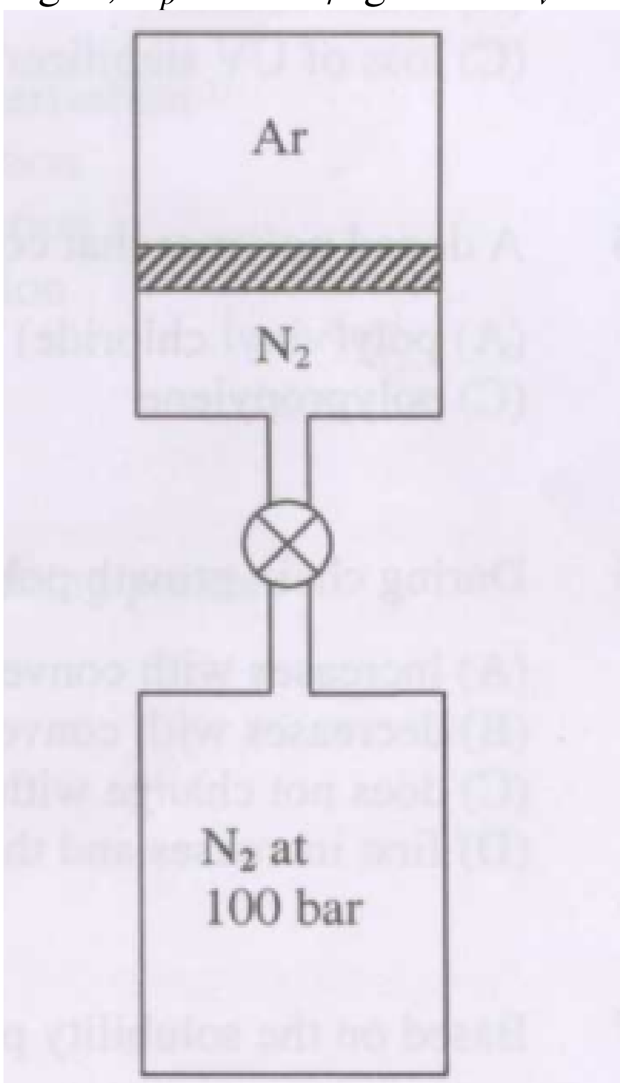
Q.22 The actual power input to the compressor (kW) is [GATE XE 2009]

A) 0.49
B) 0.99
C) 1.71
D) 2.2

LINKED ANSWER QUESTIONS

Statement for Linked Answer Questions 23 and 24:

An insulated vertical cylinder encloses 0.1 kg of argon (Ar) with the help of a frictionless non-conducting piston as shown in the figure. The mass of the piston is 5 kg and it initially rests on the bottom of the cylinder. The cylinder is connected to a nitrogen (N_2) tank at 100 bar through a pipeline fitted with a valve. The valve is opened and nitrogen is slowly admitted into the cylinder. During this operation, the piston is lifted through a height of 10 cm by the nitrogen gas. The initial pressure and temperature of argon gas are 100 kPa and 300 K respectively. The final temperature of argon is 320 K. For argon, C_p = 520 J/kgK and C_v = 312 J/kgK.



Q.23 Work done by argon during process (kJ) is [GATE XE 2009]

A) 10
B) 1.041
C) -0.624
D) -1.041

Q.24 Work done by nitrogen during the process (kJ) is [GATE XE 2009]

A) 1.046
B) 0.629
C) -1.046
D) -10

F : POLYMER SCIENCE AND ENGINEERING

Q. 1 – Q. 8 carry one mark each.

Q.1. Which of the following trends is the most appropriate for a thixotropic fluid? [GATE XE 2009]

A) Viscosity increases with increase in the rate of shear.
B) Viscosity increases with increase in the time of application of shear.
C) Viscosity decreases with increase in the time of application of shear.
D) Viscosity increases with decrease in the rate of shear.

Q.2. The temperature at which thermoforming is best carried out is [GATE XE 2009]

A) softening temperature
B) melting temperature
C) glass transition temperature
D) 10% above melting temperature

Q.3. Which of the following blends is immiscible? [GATE XE 2009]

A) SAN / PMMA
B) PE / PP
C) PC / PS
D) PET / PBT

Q.4. A flexible garden hose pipe made of PVC was observed to get hardened after a length of time. The observation is most likely due to [GATE XE 2009]

A) chain scission
B) loss of plasticizer
C) loss of UV stabilizer
D) loss of thermal stabilizer

Q.5. A doped polymer that conducts electricity is [GATE XE 2009]

A) poly(vinyl chloride)
B) polyethylene
C) polypropylene
D) polypyrrole

Q.6. During chain growth polymerization, the molecular weight of the polymer [GATE XE 2009]

A) increases with conversion
B) decreases with conversion
C) does not change with conversion
D) first increases and then decreases with conversion

Q.7. Based on the solubility parameter (δ), the best solvent for polyethylene (δ = 16.2 MPa$^{1/2}$) is [GATE XE 2009]

A) tetrahydrofuran (δ = 20.3 MPa$^{1/2}$)
B) toluene (δ = 18.3 MPa$^{1/2}$)
C) acetone (δ = 19.9 MPa$^{1/2}$)
D) methanol (δ = 29.7 MPa$^{1/2}$)

Q.8. For any polymer, the number average molecular weight (M_n), weight average molecular weight (M_w) and viscosity average molecular weight (M_v), in general, obey the following relationship: [GATE XE 2009]

A) $M_n > M_w > M_v$
B) $M_w > M_v > M_n$
C) $M_w > M_n > M_v$
D) $M_v > M_w > M_n$

Q.9 to Q.24 carry two marks each.

Q.9. Pair the items in the Column I with those in the Column II. [GATE XE 2009]

Column I (Processing step)	Column II (Item)
P. rotational molding	1. polyurethane
Q. extrusion	2. use of a gas
R. reaction injection molding	3. centrifugal force
S. blow molding	4. twin screw

A) P-3, Q-1, R-2, S-4
B) P-2, Q-4, R-3, S-1
C) P-4, Q-2, R-1, S-3
D) P-3, Q-4, R-1, S-2

Q.10. Strain, γ, in a polymer melt varies with time on application of stress s by the following relation: [GATE XE 2009]

$$\eta \frac{d\gamma}{dt} + G\gamma = s$$

If a steady shear stress, s_0, is applied, the strain at the steady state, γ_0, is given by: [GATE XE 2009]

A) $\frac{s_0}{G}$
B) $\frac{s_0}{\eta}$
C) $s_0 G$
D) $s_0 \eta$

Q.11. Match the polymerization initiator with the respective process. [GATE XE 2009]

Initiator

P. benzyl lithium
Q. tropolyn chloride
R. AIBN
S. $TiCl_3/Al(Et)_3$

Process

1. coordination polymerization
2. anionic polymerization
3. cationic polymerization
4. radical polymerization

A) P-2, Q-3, R-4, S-1
B) P-2, Q-3, R-1, S-4
C) P-3, Q-1, R-2, S-4
D) P-4, Q-2, R-1, S-3

Q.12. Arrange the following polyamides (PA) in decreasing order of their melting points: [GATE XE 2009]

I. PA 66
II. PA 6
III. PA 10
IV. PA 12

A) IV > I > II > III
B) I > II > III > IV
C) III > II > IV > I
D) II > IV > III > I

Q.13. Match the characterization technique with the most appropriate property. [GATE XE 2009]

Characterization Technique

P. infrared spectroscopy
Q. thermo-gravimetric analysis
R. transmission electron microscopy
S. differential scanning calorimetry

Property

1. melting point
2. functional group
3. degradation temperature
4. morphology

A) P-3, Q-2, R-4, S-1
B) P-3, Q-4, R-2, S-1
C) P-2, Q-1, R-4, S-3
D) P-2, Q-3, R-4, S-1

Q.14. Match the rubber ingredients with their appropriate function. [GATE XE 2009]

Rubber ingredient	**Function**
P. ZnO	1. tackifier
Q. salicylic acid	2. extender
R. ester gum	3. accelerator
S. paraffin oil	4. retarder

A) P-3, Q-4, R-1, S-2
B) P-3, Q-4, R-2, S-1
C) P-4, Q-3, R-2, S-1
D) P-4, Q-3, R-1, S-2

Q.15. At the start of a step growth polymerization there are N_0 moles of monomer A (molecular weight M_A) and N_0 moles of monomer B (molecular weight M_B). At the end of the polymerization there are N moles of polymer chains. Assuming no condensation product, the number of average molecular weight is [GATE XE 2009]

A) $\dfrac{2N_0(M_A + M_B)}{N}$
B) $\dfrac{N_0(M_A + M_B)}{N}$
C) $\dfrac{N_0(M_A + M_B)}{2N}$
D) $\dfrac{N_0^2(M_A + M_B)}{N^2}$

Q.16. The ratio of the complex dynamic modulus to the storage modulus of a polymer system with a phase angle of 45° is [GATE XE 2009]

A) 0
B) $1 - i$
C) $1 + i$
D) $1 \pm i$

Q.17. Match the additive to its most common function. [GATE XE 2009]

Additive	**Function**
P. talc	1. plasticizer
Q. carbon fibre	2. flame retardant
R. dioctyl phthalate	3. filler
S. antimony trioxide	4. reinforcement

A) P-3, Q-4, R-2, S-1
B) P-4, Q-3, R-1, S-2
C) P-4, Q-3, R-2, S-1
D) P-3, Q-4, R-1, S-2

Q.18. Match the polymer mechanical property with the appropriate testing method. [GATE XE 2009]

Mechanical property	**Testing method**
P. flexural strength	1. notched Izod
Q. impact strength	2. Shore-D
R. hardness	3. ASTM D 638
S. tensile strength	4. three-point bending

A) P-4, Q-1, R-2, S-3
B) P-3, Q-2, R-1, S-4
C) P-3, Q-1, R-2, S-4
D) P-4, Q-1, R-2, S-3

Common Data Questions

Common Data for Questions 19 and 20:

An aligned short carbon fibre reinforced polyester composite has a fibre content of 40% by volume. The elastic modulus of carbon fibre and polyester resin are 250 GPa and 35 GPa, respectively. The fibre diameter is 5 μm and the ultimate tensile strength of the fibre is 1240 MPa.

Q.19. The modulus of the composite is [GATE XE 2009]

A) 121 GPa
B) 215 GPa
C) 285 GPa
D) 142.5 GPa

Q.20. The fibre-matrix bond strength, assuming a critical fibre length of 12 mm, is [GATE XE 2009]

A) 258 MPa
B) 2.58 MPa
C) 25.8 MPa
D) 0.258 MPa

Common Data for Questions 21 and 22:
A plasticating screw of an injection molding unit injects 0.1 L/s of polymer through a mold, which is a cylindrical tube having a diameter of 20 mm and a length of 100 mm. The pressure drop across the mold is 100 MPa.

Q.21. The shear stress exerted by the polymer on the wall of the mold is [GATE XE 2009]

A) 2.5 MPa
B) 10 MPa
C) 5 MPa
D) 1 MPa

Q.22. The power consumed by the plasticizing screw is [GATE XE 2009]

A) 5 kW
B) 1 kW
C) 2.5 kW
D) 10 kW

Linked Answer Questions
Statement for Linked Answer Questions 23 and 24:
The density of a poly(ethylene terephthalate) (PET) sample is 1.407 g/cm^3, and the heat of fusion of the sample obtained from differential scanning calorimetry (DSC) is 54.6 J/g. The density of the PET crystalline phase is 1.515 g/cm^3 and of the PET amorphous phase is 1.335 g/cm^3.

Q.23. The fractional crystallinity of the sample is [GATE XE 2009] [GATE XE 2009]

A) 0.23
B) 0.36
C) 0.40
D) 0.43

Q.24. The heat of fusion of the PET crystalline phase is [GATE XE 2009]

A) 21.8 J/g
B) 136.5 J/g
C) 68.2 J/g
D) 158.3 J/g

G : FOOD TECHNOLOGY

Q. 1 – Q. 8 carry one mark each.

Q.1. Among the following amino acids, the one that has a disulfide linkage is [GATE XE 2009]

A) (-)-proline
B) (-)-cystine
C) (-)-cysteine
D) (-)-histidine

Q.2. The method of packaging of food under sterile environment, after independently sterilizing the food and packing material, is termed as [GATE XE 2009]

A) active packaging
B) vacuum packaging
C) flexible packaging
D) aseptic packaging

Q.3. Mild heat treatment of food to inactivate enzymes that would otherwise cause its deterioration during frozen storage is termed as [GATE XE 2009]

A) stewing
B) blanching
C) boiling
D) pasteurization

Q.4. The most suitable evaporator for concentration of fruit juices is [GATE XE 2009]

A) agitated film evaporator
B) falling film evaporator
C) long tube evaporator
D) short tube evaporator

Q.5. Souring of milk is primarily due to the conversion of lactose to [GATE XE 2009]

A) lactobionic acid
B) lactic acid
C) lactol
D) lactonic acid

Q.6. The selective media used for isolating *Escherichia coli* is [GATE XE 2009]

A) blood agar
B) mannitol salt agar
C) eosin methylene blue agar
D) rose bengal malt extract agar

Q.7. A method in which continuous electric current is passed through food to heat it rapidly while maintaining quality is called [GATE XE 2009]

A) microwave cooking
B) irradiation
C) ohmic heating
D) sonication

Q.8. A cyclone separator is used for the separation of [GATE XE 2009]

A) particles from liquid
B) liquid droplets from gas
C) fine particles from gas
D) fine particles from solids

Q.9 to Q.24 carry two marks each.

Q.9. Match the items in Group I with the most appropriate items in Group II. [GATE XE 2009]

Group I	**Group II**
P. Tocopherol	1. Oxygen binding
Q. Myoglobin	2. Yellow pigment
R. Crocetin	3. Antioxidant
S. Catechin	4. Green pigment
	5. Tanning agent

A) P – 3, Q – 1, R – 2, S – 5
B) P – 1, Q – 3, R – 4, S – 5
C) P – 3, Q – 1, R – 5, S – 2
D) P – 1, Q – 3, R – 5, S – 4

Q.10. Two key reactions involved in enzymatic browning of food are [GATE XE 2009]

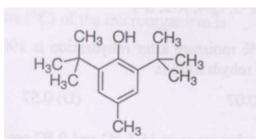
A) hydroxylation of phenol to *p*-dihydroxybenzene followed by its oxidation to *p*-quinone

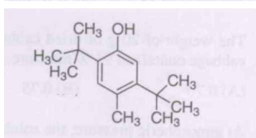
B) oxidation of phenol to *p*-quinone followed by its reduction to *p*-dihydroxybenzene

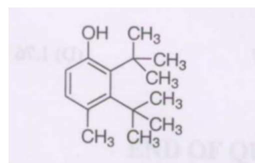
C) oxidation of phenol to *o*-quinone followed by its reduction to *o*-dihydroxybenzene

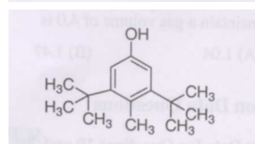
D) hydroxylation of phenol to *o*-dihydroxybenzene followed by its oxidation to *o*-quinone

Q.11. The correct structure of synthetic antioxidant BHT (butylated hydroxy toluene) is [GATE XE 2009]

A) 

B) 

C) 

D) 

Q.12. Wet grain was dried from an initial moisture content of 50% to a final moisture content of 20% (on wet basis). The amount of moisture removed to get 1000 kg of the final product is [GATE XE 2009]

A) 800 kg

B) 200 kg

C) 300 kg

D) 600 kg

Q.13. The correct pair of food borne disease and its causative microorganism is [GATE XE 2009]

A) Hemorrhagic inflammation of intestinal wall – *Campylobacter jejuni*

B) Paratyphoid fever – *Staphylococcus aureus*

C) Typhoid fever – *Salmonella*

typhimurium *biflexa*

D) Listerellosis – *Leptospira*

Q.14. Fermentation process of vinegar production involves[GATE XE 2009]

A) ethanolic fermentation followed by reduction of ethanol

B) direct acetic acid production without ethanolic fermentation

C) anaerobic fermentation of acetone

D) ethanolic fermentation followed by oxidation of ethanol

Q.15. In a double pipe heat exchanger the outer diameter of the inner pipe is d_1 and the inner diameter of the outer pipe is d_2. The equivalent diameter of the annulus for heat transfer is [GATE XE 2009]

A) $(d_1 + d_2)/2$

B) $(d_2^2 - d_1^2)/d_1$

C) $(d_2 - d_1)$

D) $(d_2^2 - d_1^2)/d_2$

Q.16. Match various phases of a typical bacterial growth cycle in Group I with most appropriate bacterial activity in Group II. [GATE XE 2009]

Group I

P. Lag phase

Q. Exponential phase

R. Stationary phase

S. Decline phase

Group II

1. Number of viable cells decreases
2. Growth ceases and population remains constant
3. Preparatory phase for cell division
4. Cells divide steadily at constant rate
5. Cells aggregate

A) P – 4, Q – 3, R – 2, S – 1 C) P – 2, Q – 1, R – 3, S – 4
B) P – 5, Q – 4, R – 1, S – 2 D) P – 3, Q – 4, R – 2, S – 1

Q.17. The weight of 20 g of dried cabbage containing 5% moisture after rehydration is 190 g. If the fresh cabbage contained 93% moisture, the coefficient of rehydration is[GATE XE 2009]

A) 0.70 C) 0.07
B) 0.75 D) 0.57

Q.18. At atmospheric pressure, the solubilities of CO_2 in a beverage at 15.5°C and 0°C are 1.0 volume and 1.7 volume respectively. The pressure (in atm.) required to carbonate the beverage at 4.5°C so as to maintain a gas volume of 4.0 is [GATE XE 2009]

A) 1.04 C) 1.67
B) 1.47 D) 1.76

Common Data Questions
Common Data for Questions 19 and 20:

The partial pressure and vapour pressure of water vapour in air at 27 °C and 1 atm. are 0.028 and 0.035 atm respectively. (Molecular weight of air is 29)

Q.19. The humidity of air (kg water /kg air) is[GATE XE 2009]

A) 0.0496 C) 0.018
B) 0.082 D) 0.046

Q.20. The percentage relative humidity of air is [GATE XE 2009]

A) 46
B) 80
C) 20
D) 35

Q.21. Fermentation process of vinegar production involves[GATE XE 2009]

A) ethanolic fermentation followed by reduction of ethanol
B) direct acetic acid production without ethanolic fermentation
C) anaerobic fermentation of acetone
D) ethanolic fermentation followed by oxidation of ethanol

Q.22. In a double pipe heat exchanger the outer diameter of the inner pipe is d_1 and the inner diameter of the outer pipe is d_2. The equivalent diameter of the annulus for heat transfer is [GATE XE 2009]

A) $(d_1 + d_2)/2$
B) $(d_2^2 - d_1^2)/d_1$
C) $(d_2 - d_1)$
D) $(d_2^2 - d_1^2)/d_2$

Q.23. Match various phases of a typical bacterial growth cycle in Group I with most appropriate bacterial activity in Group II. [GATE XE 2009]

Group I

P. Lag phase
Q. Exponential phase
R. Stationary phase
S. Decline phase

Group II

1. Number of viable cells decreases
2. Growth ceases and population remains constant
3. Preparatory phase for cell division
4. Cells divide steadily at constant rate
5. Cells aggregate

A) P – 4, Q – 3, R – 2, S – 1 C) P – 2, Q – 1, R – 3, S – 4
B) P – 5, Q – 4, R – 1, S – 2 D) P – 3, Q – 4, R – 2, S – 1

Q.24. The weight of 20 g of dried cabbage containing 5% moisture after rehydration is 190 g. If the fresh cabbage contained 93% moisture, the coefficient of rehydration is[GATE XE 2009]

A) 0.70 C) 0.07
B) 0.75 D) 0.57

Q.25. At atmospheric pressure, the solubilities of CO_2 in a beverage at 15.5°C and 0°C are 1.0 volume and 1.7 volume respectively. The pressure (in atm.) required to carbonate the beverage at 4.5°C so as to maintain a gas volume of 4.0 is [GATE XE 2009]

A) 1.04 C) 1.67
B) 1.47 D) 1.76

Common Data Questions
Common Data for Questions 19 and 20:

The partial pressure and vapour pressure of water vapour in air at 27 °C and 1 atm. are 0.028 and 0.035 atm respectively. (Molecular weight of air is 29)

Q.26. The humidity of air (kg water /kg air) is[GATE XE 2009]

A) 0.0496 C) 0.018
B) 0.082 D) 0.046

Q.27. The percentage relative humidity of air is [GATE XE 2009]

A) 46
C) 20
B) 80
D) 35

Common Data for Questions 21 and 22:

In an ice-cream manufacturing plant, 1450 litres of ice-cream was obtained from 1000 litres of ice-cream mix. The composition of ice-cream mix was as follows: Fat: 12.0%, Sugar: 15.0%, Milk solids not fat: 11.0%, Stabilizer & emulsifier: 0.3%.

Q.21. Specific gravity of ice-cream mix at 16°C is [GATE XE 2009]

A) 1.096
C) 1.906
B) 0.196
D) 0.916

Q.22. Percent over run in the ice-cream was [GATE XE 2009]

A) 35
C) 40
B) 50
D) 45

Linked Answer Questions
Statement for Linked Answer Questions 23 and 24:

In an experiment, the thermal death time (TDT) values for a microorganism were obtained as 2.78 minutes and 9.98 minutes at 121.1°C and 115.5°C, respectively.

Q.23. The z-value (°C) of the microorganism is [GATE XE 2009]

A) 9.91
C) 1.99
B) 9.19
D) 0.19

Q.24. The TDT value (minutes) at 110°C is [GATE XE 2009]

A) 35.1
B) 25.8
C) 12.9
D) 21.9