General Aptitude (GA)

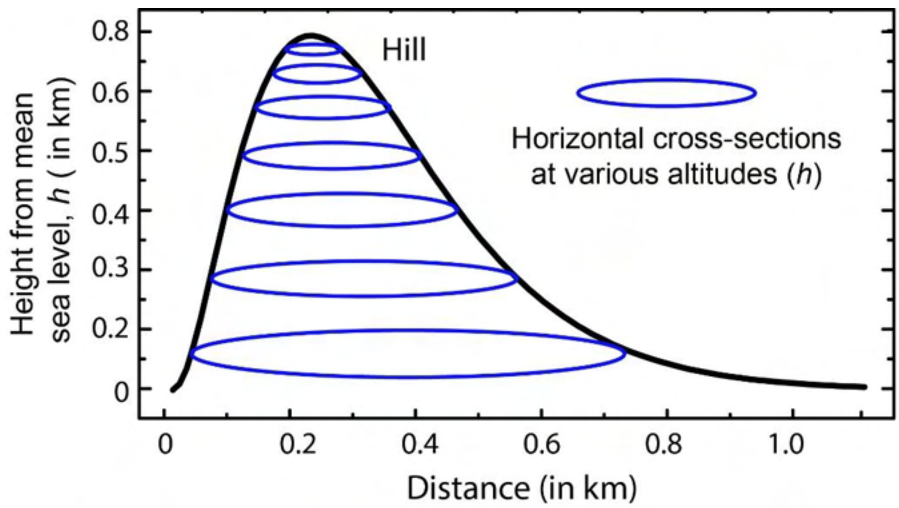
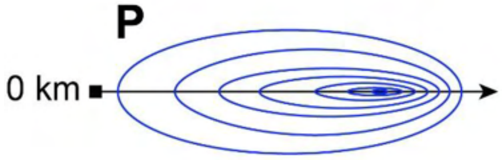
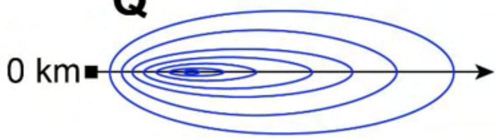
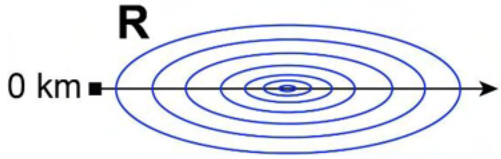
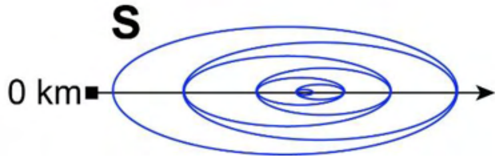
Q.1 – Q.5 Carry ONE mark Each

Q.1	The village was nestled in a green spot, _______ the ocean and the hills.
(A)	through
(B)	in
(C)	at
(D)	between

Q.2	Disagree : Protest : : Agree : _______ (By word meaning)
(A)	Refuse
(B)	Pretext
(C)	Recommend
(D)	Refute

Q.3	A ‘frabjous’ number is defined as a 3 digit number with all digits odd, and no two adjacent digits being the same. For example, 137 is a frabjous number, while 133 is not. How many such frabjous numbers exist?
(A)	125
(B)	720
(C)	60
(D)	80

Q.4	Which one among the following statements must be TRUE about the mean and the median of the scores of all candidates appearing for GATE 2023?
(A)	The median is at least as large as the mean.
(B)	The mean is at least as large as the median.
(C)	At most half the candidates have a score that is larger than the median.
(D)	At most half the candidates have a score that is larger than the mean.

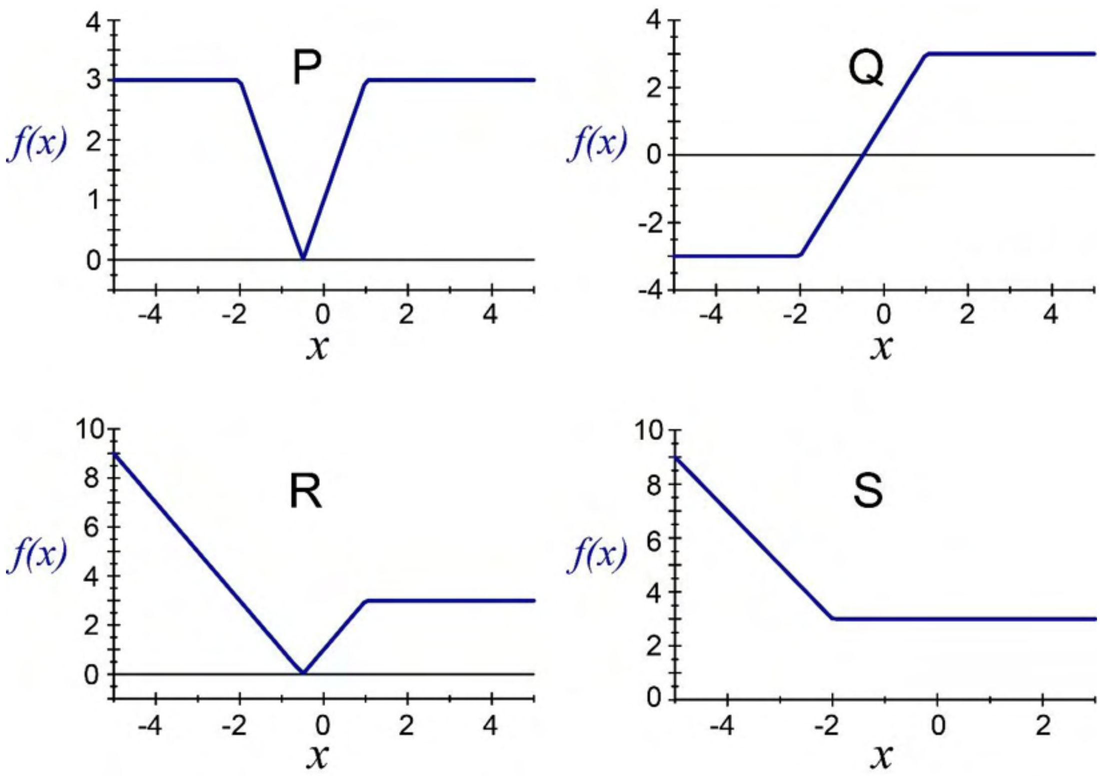
Q.5	In the given diagram, ovals are marked at different heights (*h*) of a hill. Which one of the following options **P**, **Q**, **R**, and **S** depicts the top view of the hill?
	 **P**  **Q**  **R**  **S** 
(A)	**P**
(B)	**Q**
(C)	**R**
(D)	**S**

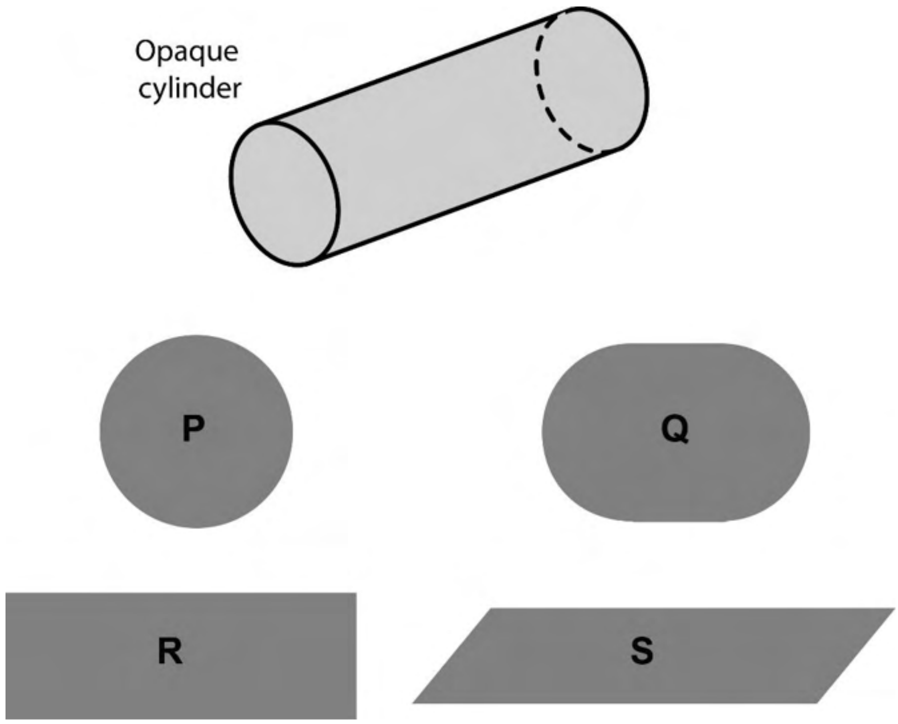
Q.6 – Q.10 Carry TWO marks Each

Q.6	Residency is a famous housing complex with many well-established individuals among its residents. A recent survey conducted among the residents of the complex revealed that all of those residents who are well established in their respective fields happen to be academicians. The survey also revealed that most of these academicians are authors of some best-selling books. Based only on the information provided above, which one of the following statements can be logically inferred with *certainty*?
(A)	Some residents of the complex who are well established in their fields are also authors of some best-selling books.
(B)	All academicians residing in the complex are well established in their fields.
(C)	Some authors of best-selling books are residents of the complex who are well established in their fields.
(D)	Some academicians residing in the complex are well established in their fields.

Q.7	Ankita has to climb 5 stairs starting at the ground, while respecting the following rules: 1. At any stage, Ankita can move either one or two stairs up. 2. At any stage, Ankita cannot move to a lower step. Let $F(N)$ denote the number of possible ways in which Ankita can reach the N^{th} stair. For example, $F(1) = 1,\ F(2) = 2,\ F(3) = 3$. The value of $F(5)$ is ________.
(A)	8
(B)	7
(C)	6
(D)	5

Q.8	The information contained in DNA is used to synthesize proteins that are necessary for the functioning of life. DNA is composed of four nucleotides: Adenine (A), Thymine (T), Cytosine (C), and Guanine (G). The information contained in DNA can then be thought of as a sequence of these four nucleotides: A, T, C, and G. DNA has coding and non-coding regions. Coding regions—where the sequence of these nucleotides are read in groups of three to produce individual amino acids—constitute only about 2% of human DNA. For example, the triplet of nucleotides CCG codes for the amino acid glycine, while the triplet GGA codes for the amino acid proline. Multiple amino acids are then assembled to form a protein. Based only on the information provided above, which of the following statements can be logically inferred with *certainty*? (i) The majority of human DNA has no role in the synthesis of proteins. (ii) The function of about 98% of human DNA is not understood.
(A)	only (i)
(B)	only (ii)
(C)	both (i) and (ii)
(D)	neither (i) nor (ii)

Q.9	Which one of the given figures P, Q, R and S represents the graph of the following function? $$f(x) = \| \|x+2\| - \|x-1\| \|$$
	
(A)	P
(B)	Q
(C)	R
(D)	S

Q.10	An opaque cylinder (shown below) is suspended in the path of a parallel beam of light, such that its shadow is cast on a screen oriented perpendicular to the direction of the light beam. The cylinder can be reoriented in any direction within the light beam. Under these conditions, which one of the shadows **P**, **Q**, **R**, and **S** is NOT possible?
	
(A)	**P**
(B)	**Q**
(C)	**R**
(D)	**S**

Engineering Mathematics: XE-A (Compulsory)

XE-A: Q.11 – Q.17 Carry ONE mark Each

Q.11	Let A be a 3×3 real matrix having eigenvalues $1, 2,$ and 3. If $B = A^2 + 2A + I$, where I is the 3×3 identity matrix, then the eigenvalues of B are
(A)	$4, 9, 16$
(B)	$1, 2, 3$
(C)	$1, 4, 9$
(D)	$4, 16, 25$
Q.12	Let $f: \mathbb{R}^2 \to \mathbb{R}$ be a function defined by
	$$f(x,y) = \begin{cases} \dfrac{xy}{\lvert x \rvert + y} & , \quad y \neq -\lvert x \rvert \\ 0 & , \quad \text{otherwise.} \end{cases}$$ Then which one of the following statement is TRUE?
(A)	f is NOT continuous at $(0,0)$.
(B)	$\frac{\partial f}{\partial x}(0,0) = 0$, and $\frac{\partial f}{\partial y}(0,0) = 1$.
(C)	$\frac{\partial f}{\partial x}(0,0) = 1$, and $\frac{\partial f}{\partial y}(0,0) = 0$.
(D)	$\frac{\partial f}{\partial x}(0,0) = 1$, and $\frac{\partial f}{\partial y}(0,0) = 1$.

Q.13	If the quadrature formula
	$$\int_{-1}^{1} f(x)dx \approx \frac{1}{9}\left(c_1 f(-1) + c_2 f\left(\frac{1}{2}\right) + c_3 f(1)\right)$$
	is exact for all polynomials of degree less than or equal to 2, then
(A)	$c_1 + \frac{c_2}{4} + c_3 = 6$
(B)	$c_1 + \frac{c_2}{3} + c_3 = 4$
(C)	$c_1 + \frac{c_2}{2} + c_3 = 2$
(D)	$c_1 + c_2 + c_3 = 5$
Q.14	The second smallest eigenvalue of the eigenvalue problem
	$\frac{d^2y}{dx^2} + (\lambda - 3)y = 0, \quad y(0) = y(\pi) = 0,$
	is
(A)	4
(B)	3
(C)	7
(D)	9

Q.15	Which one of the following functions is differentiable at $z = 0$ but NOT differentiable at any other point in the complex plane $\mathbb{C}$?
(A)	$f(z) = z\|z\|, \quad z \in \mathbb{C}$
(B)	$f(z) = \sin(z), \quad z \in \mathbb{C}$
(C)	$f(z) = \begin{cases} e^{\frac{1}{z}}, & z \neq 0 \\ 0, & z = 0 \end{cases} \quad \text{for} \quad z \in \mathbb{C}$
(D)	$f(z) = e^{-z^2}, \quad z \in \mathbb{C}$

Q.16	If the polynomial
	$P(x) = a_0 + a_1 x + a_2 x(x-1) + a_3 x(x-1)(x-2)$
	interpolates the points $(0, 2), (1, 3), (2, 2)$, and $(3, 5)$, then the value of $P\left(\frac{5}{2}\right)$ is __________ (*round off to 2 decimal places*).
Q.17	The value of m for which the vector field
	$\vec{F}(x, y) = (4x^m y^2 - 2\,x\,y^m)\hat{\imath} + (2x^4 y - 3x^2 y^2)\hat{\jmath}$
	is a conservative vector field, is ____________________ (*in integer*).

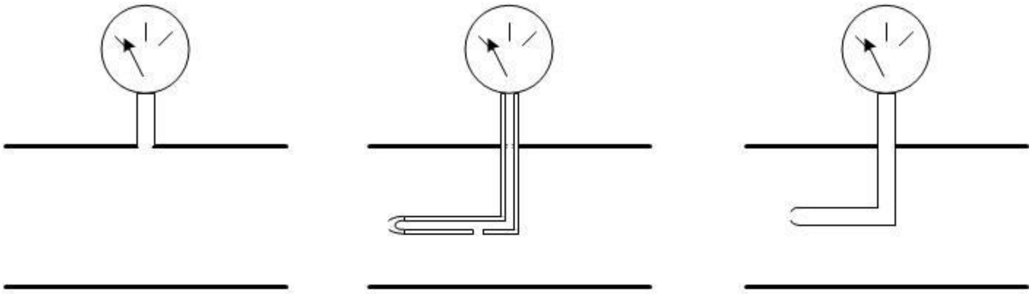
XE-A: Q.18 – Q.21 Carry TWO marks Each

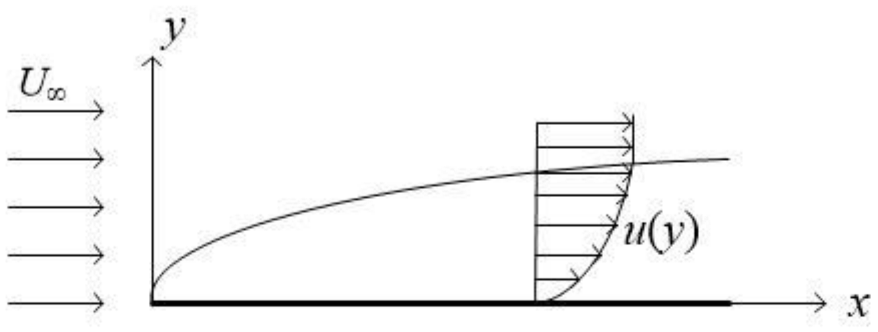
Q.18	Let
	$P = \begin{bmatrix} 4 & -2 & 2 \\ 6 & -3 & 4 \\ 3 & -2 & 3 \end{bmatrix}$, and $Q = \begin{bmatrix} 3 & -2 & 2 \\ 4 & -4 & 6 \\ 2 & -3 & 5 \end{bmatrix}$.
	The eigenvalues of both P and Q are $1, 1,$ and 2. Which one of the following statements is TRUE?
(A)	Both P and Q are diagonalizable
(B)	P is diagonalizable but Q is NOT diagonalizable
(C)	P is NOT diagonalizable but Q is diagonalizable
(D)	Both P and Q are NOT diagonalizable
Q.19	The surface area of the portion of the paraboloid
	$z = x^2 + y^2$
	that lies between the planes $z = 0$ and $z = \frac{1}{4}$ is
(A)	$\frac{\pi}{6}(2\sqrt{2} - 1)$
(B)	$\frac{\pi}{2}(2\sqrt{2} - 1)$
(C)	$\pi(2\sqrt{2} - 1)$
(D)	$\frac{\pi}{3}(2\sqrt{2} - 1)$

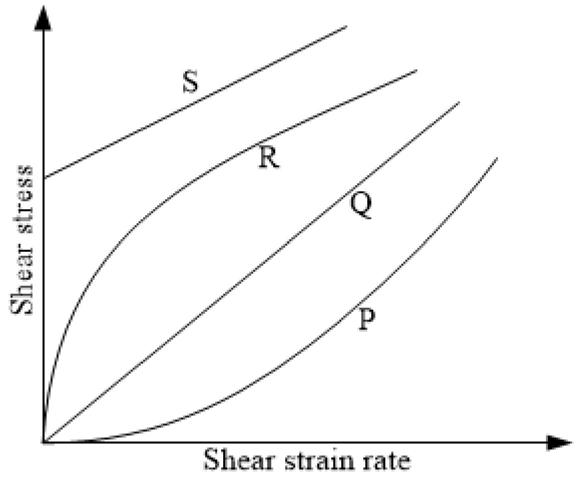
Q.20	The probability of a person telling the truth is $\frac{4}{6}$. An unbiased die is thrown by the same person twice and the person reports that the numbers appeared in both the throws are same. Then the probability that actually the numbers appeared in both the throws are same is ___________ (*round off to 2 decimal places*).
Q.21	Let $u(x,t)$ be the solution of the initial boundary value problem
	$\frac{\partial u}{\partial t} - \frac{\partial^2 u}{\partial x^2} = 0, \quad x \in (0,2),\ t > 0$ $u(x,0) = \sin(\pi x),\ \ x \in (0,2)$ $u(0,t) = u(2,t) = 0.$
	Then the value of $e^{\pi^2}\left(u\left(\frac{1}{2},1\right) - u\left(\frac{3}{2},1\right)\right)$ is ___________ (*in integer*).

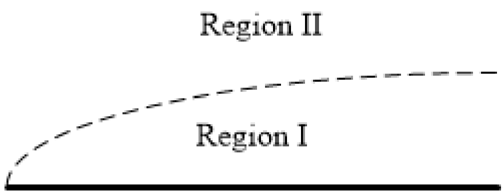
Fluid Mechanics (XE-B)

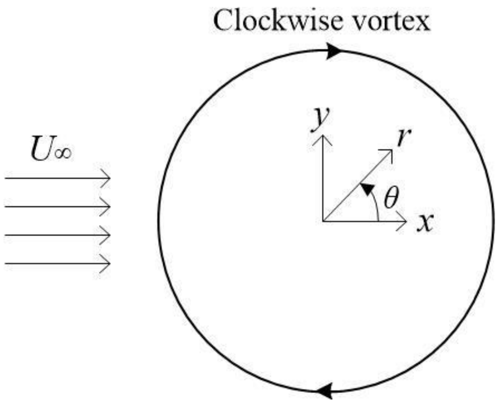
XE-B: Q.22 – Q.30 Carry ONE mark Each

Q.22	Match the following measuring instruments with the appropriate figures. I – Pitot probe II – Pitot-static probe III – Piezometer
	 (P) (Q) (R)
(A)	I – P; II – Q; III – R
(B)	I – R; II – Q; III – P
(C)	I – R; II – P; III – Q
(D)	I – Q; II – P; III – R

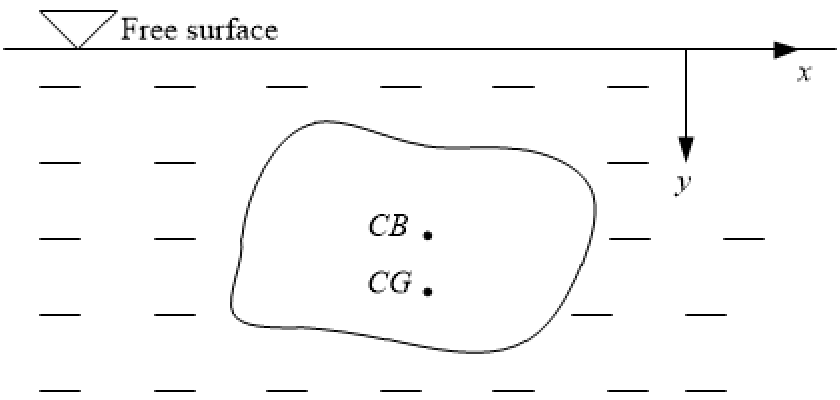
Q.23	Among the following non-dimensional numbers, which one characterizes periodicity present in a transient flow?
(A)	Froude number
(B)	Strouhal number
(C)	Peclet number
(D)	Lewis number
Q.24	For an incompressible boundary layer flow over a flat plate shown in the figure, the momentum thickness is expressed as
	
(A)	$\int_0^\infty \frac{u}{U_\infty} dy$
(B)	$\int_0^\infty \left(1-\frac{u}{U_\infty}\right) dy$
(C)	$\int_0^\infty \frac{u}{U_\infty}\left(1-\frac{u}{U_\infty}\right) dy$
(D)	$\int_0^\infty \left(1-\frac{u^2}{U_\infty^2}\right) dy$

Q.25	Among the shear stress versus shear strain rate curves shown in the figure, which one corresponds to a shear thinning fluid?
	
(A)	P
(B)	Q
(C)	R
(D)	S

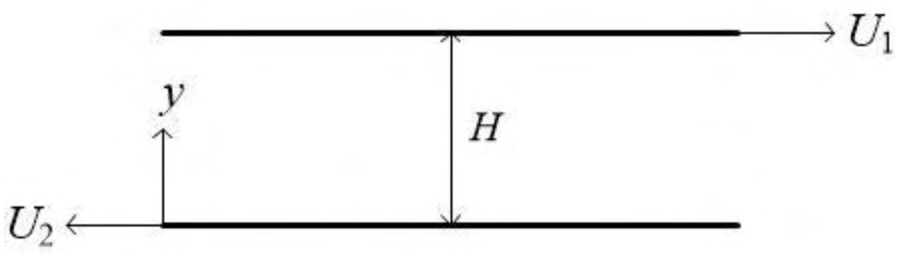
Q.26	Consider steady incompressible flow over a flat plate, where the dashed line represents the edge of the boundary layer, as shown in the figure. Which one among the following statements is true?
	
(A)	Bernoulli's equation can be applied in Region I between any two arbitrary points.
(B)	Bernoulli's equation can be applied in Region I only along a streamline.
(C)	Bernoulli's equation cannot be applied in Region II.
(D)	Bernoulli's equation cannot be applied in Region I.

Q.27	An inviscid steady incompressible flow is formed by combining a uniform flow with velocity U_∞ and a clockwise vortex of strength K at the origin, as shown in the figure. Velocity potential (ϕ) for the combined flow in polar coordinate (r, θ) is
	
(A)	$\phi = \dfrac{K\theta}{2\,\pi} - U_\infty r\ \cos\theta$
(B)	$\phi = \dfrac{K\theta}{2\,\pi} - U_\infty r\ \sin\theta$
(C)	$\phi = K\ln r + U_\infty r\ \cos\theta$
(D)	$\phi = -K\ln r + U_\infty r\ \sin\theta$

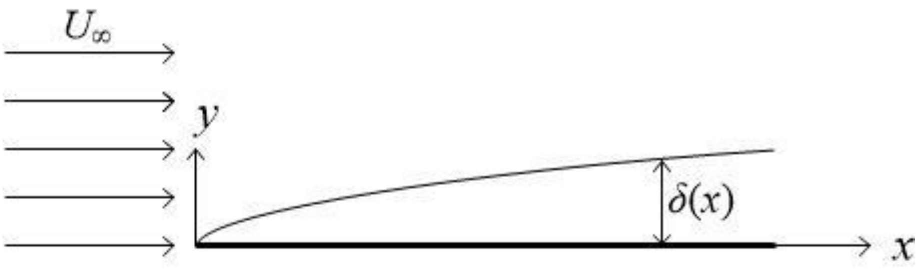
Q.28	Which of the following statements are true? (i) Conservation of mass for an unsteady incompressible flow can be represented as $\nabla \cdot \vec{V} = 0$, where $\vec{V}$ denotes velocity vector. (ii) Circulation is defined as the line integral of vorticity about a closed curve. (iii) For some fluids, shear stress can be a nonlinear function of the shear strain rate. (iv) Integration of the Bernoulli's equation along a streamline under steady-state leads to the Euler's equation.
(A)	(i), (ii) and (iv) only
(B)	(i), (ii) and (iii) only
(C)	(i) and (iii) only
(D)	(ii) and (iv) only
Q.29	For a two-dimensional flow field given as $\vec{V} = -x\hat{\imath} + y\hat{\jmath}$, a streamline passes through points (2, 1) and (5, p). The value of p is
(A)	5
(B)	5/2
(C)	2/5
(D)	2

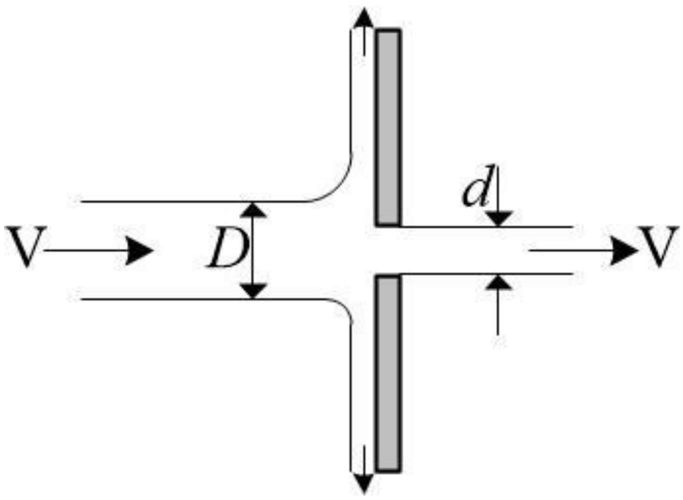
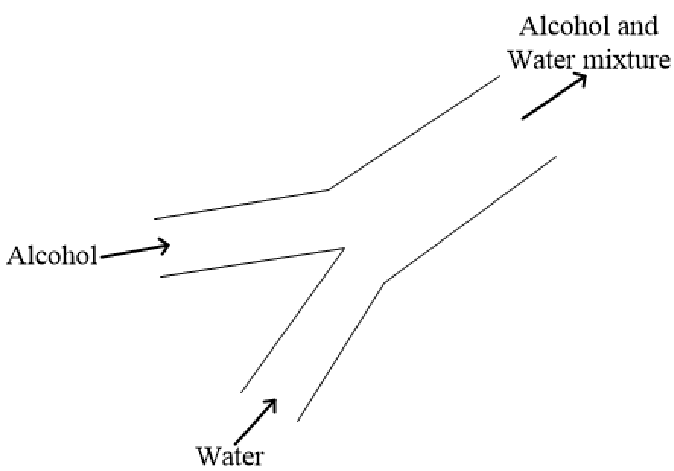
Q.30	A stationary object is fully submerged in a static fluid, as shown in the figure. Here, CG and CB stand for center of gravity and center of buoyancy, respectively. Which one(s) among the following statements is/are true?
	
(A)	The object is in stable equilibrium if $y_{CG} > y_{CB}$.
(B)	The object is in stable equilibrium if $y_{CG} < y_{CB}$.
(C)	The object is in neutral equilibrium if $y_{CG} = y_{CB}$.
(D)	The object is in unstable equilibrium if $y_{CG} = y_{CB}$.

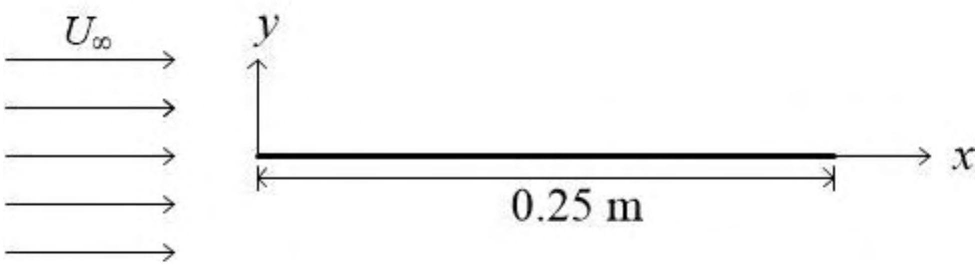
XE-B: Q.31 – Q.43 Carry TWO marks Each

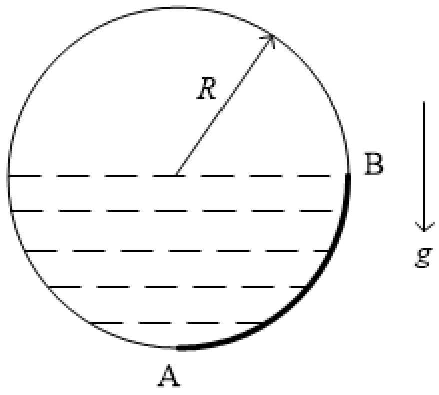
Q.31	Consider steady fully-developed incompressible flow of a Newtonian fluid between two infinite parallel flat plates. The plates move in the opposite directions, as shown in the figure. In the absence of body force and pressure gradient, the ratio of shear stress at the top surface ($y = H$) to that at the bottom surface ($y = 0$) is
	
(A)	1
(B)	$\frac{U_1}{U_2}$
(C)	$\frac{U_1 - U_2}{U_2}$
(D)	$\frac{U_1 + U_2}{U_2}$

Q.32	A two-dimensional incompressible flow field is defined as, $$\vec{V}(x,y) = (Axy)\,\hat{\imath} + (By^2)\,\hat{\jmath}$$ where, A and B are constants. The dynamic viscosity of the Newtonian fluid is μ. In the absence of body force, which among the following expressions represents the pressure gradient at the location (5, 0) in the concerned flow field?
(A)	$\mu A(5\,\hat{\imath} + \,\hat{\jmath})$
(B)	$\mu(-5B\,\hat{\imath} + A\,\hat{\jmath})$
(C)	$\mu A(-\hat{\jmath})$
(D)	$\mu A(5\,\hat{\imath})$
Q.33	For a potential flow, the fluid velocity is given by $\vec{V}(x,y) = u\hat{\imath} + v\hat{\jmath}$. The slope of the potential line at (x,y) is
(A)	$\frac{u}{v}$
(B)	$\frac{v}{u}$
(C)	$-\frac{u}{v}$
(D)	$-\frac{v}{u}$

Q.34	Consider steady incompressible flow of a Newtonian fluid over a horizontal flat plate, as shown in the figure. The boundary layer thickness is proportional to
	
(A)	$x^{1/4}$
(B)	$x^{1/2}$
(C)	$x^{-1/2}$
(D)	x^2
Q.35	In a steady two-dimensional compressible flow, u and v are the x- and y-components of flow velocity, respectively and ρ is the fluid density. Among the following pairs of relations, which one(s) perfectly satisfies/satisfy the definition of stream function, ψ, for this flow?
(A)	$u = \frac{\partial \psi}{\partial y}$ and $v = -\frac{\partial \psi}{\partial x}$
(B)	$u = -\frac{\partial \psi}{\partial x}$ and $v = -\frac{\partial \psi}{\partial y}$
(C)	$\rho u = \frac{\partial \psi}{\partial y}$ and $\rho v = -\frac{\partial \psi}{\partial x}$
(D)	$\rho u = -\frac{\partial \psi}{\partial y}$ and $\rho v = \frac{\partial \psi}{\partial x}$

Q.36	A water jet (density = 1000 kg/m^3) is approaching a vertical plate, having an orifice at the center, as shown in the figure. While a part of the jet passes through the orifice, remainder flows along the plate. Neglect friction and assume both the inlet and exit jets to have circular cross-sections. If V = 5 m/s, D = 100 mm and d = 25 mm, magnitude of the horizontal force (in N, *rounded off to one decimal place*) required to hold the plate in its position is ___________.
	
Q.37	Water (density = 1000 kg/m^3) and alcohol (specific gravity = 0.7) enter a Y-shaped channel at flow rates of 0.2 m^3/s and 0.3 m^3/s, respectively. Their mixture leaves through the other end of the channel, as shown in the figure. The average density (in kg/m^3) of the mixture is _______.
	

Q.38	The velocity and acceleration of a fluid particle are given as $\vec{V} = (-\hat{\imath} + 2\hat{\jmath})\ \mathrm{m/s}$ and $\vec{a} = (-2\hat{\imath} - 4\hat{\jmath})\ \mathrm{m/s^2}$, respectively. The magnitude of the component of acceleration (in $\mathrm{m/s^2}$, *rounded off to two decimal places*) of the fluid particle along the streamline is ________.
Q.39	A hydraulic turbine with rotor diameter of 100 mm produces 200 W of power while rotating at 300 rpm. Another dynamically-similar turbine rotates at a speed of 1500 rpm. Consider both turbines to operate with the same fluid (identical density and viscosity), and neglect any gravitational effect. Then the power (in W, *rounded off to nearest integer*) produced by the second turbine is ________________.
Q.40	Water (density = 1000 kg/m^3) flows steadily with a flow rate of 0.05 m^3/s through a venturimeter having throat diameter of 100 mm. If the pipe diameter is 200 mm and losses are negligible, the pressure drop (in kPa, *rounded off to one decimal place*) between an upstream location in the pipe and the throat (both at the same elevation) is ________.
Q.41	Water flows around a thin flat plate (0.25 m long, 2 m wide) with a free stream velocity (U_∞) of 1 m/s, as shown in the figure. Consider linear velocity profile $\left(\frac{u}{U_\infty} = \frac{y}{\delta}\right)$ for which the laminar boundary layer thickness is expressed as $\delta = \frac{3.5x}{\sqrt{Re_x}}$. For water, density = 1000 kg/m^3 and dynamic viscosity = 0.001 kg/m.s. Net drag force (in N, *rounded off to two decimal places*) acting on the plate, neglecting the end effects, is _________.
	

Q.42	Axial velocity profile $u(r)$ for an axisymmetric flow through a circular tube of radius R is given as, $$\frac{u(r)}{U} = \left(1 - \frac{r}{R}\right)^{1/n}$$ where U is the centerline velocity. If V refers to the area-averaged velocity (volume flow rate per unit area), then the ratio V/U for $n = 1$ (*rounded off to two decimal places*) is ________________.
Q.43	A stationary circular pipe of radius $R = 0.5$ m is half filled with water (density $= 1000\ \mathrm{kg/m^3}$), whereas the upper half is filled with air at atmospheric pressure, as shown in the figure. Acceleration due to gravity is $g = 9.81\ \mathrm{m/s^2}$. The magnitude of the force per unit length (in kN/m, *rounded off to one decimal place*) applied by water on the pipe section AB is ________.
	

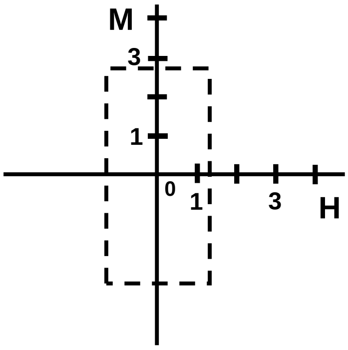
Material Science (XE-C)

XE-C: Q.44 – Q.52 Carry ONE mark Each

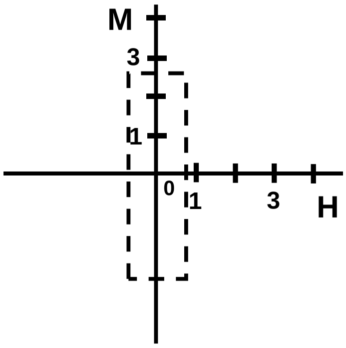
Q.44	In age-hardening of an aluminium alloy, the purpose of solution treatment followed by quenching is to
(A)	form martensitic structure
(B)	increase the size of the precipitates
(C)	form supersaturated solid solution
(D)	form precipitates at the grain boundaries

Q.45 The magnetization (M) – magnetic field (H) curves for four different materials are given below. Which one of these materials is most suitable for use as a permanent magnet?

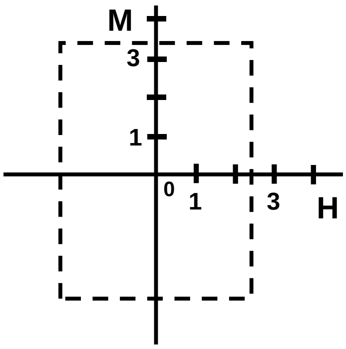
(A)



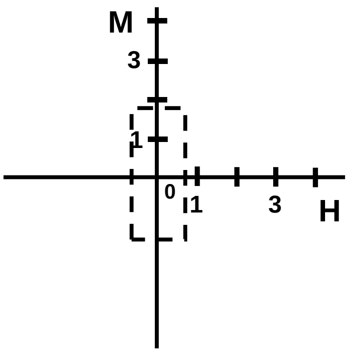
(B)

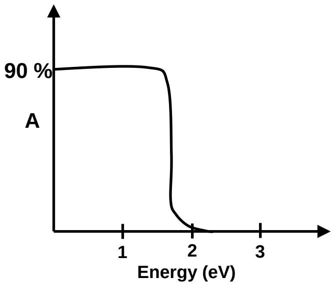
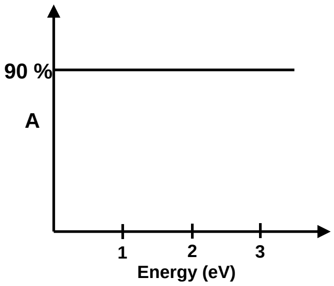
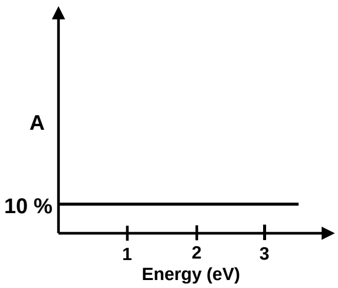
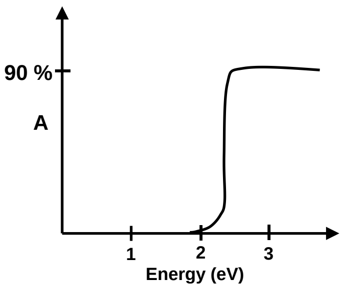


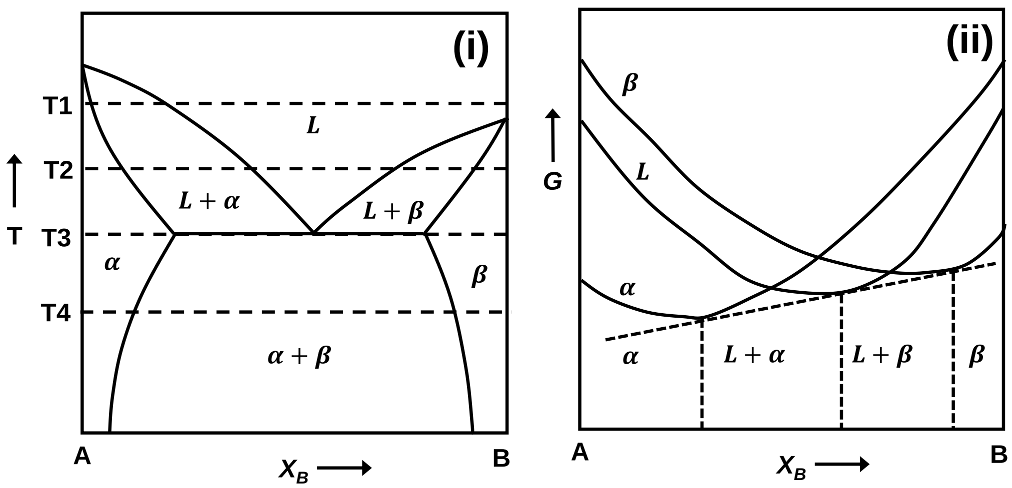
(C)



(D)



Q.46	The band gap of a semiconducting material is ~ 2 eV. Which one of the following absorption (A) vs. energy (in eV) curves is correct?
(A)	
(B)	
(C)	
(D)	

Q.47	Figures (i) and (ii) show a binary phase diagram and the corresponding Gibbs free energy (G) vs. composition (X_B) diagram, respectively. Figure (ii) corresponds to which one of the temperatures shown in Figure (i)?
	
(A)	T1
(B)	T2
(C)	T3
(D)	T4

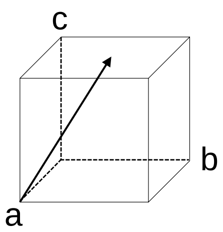
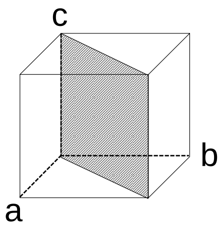
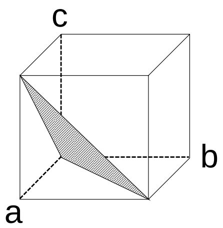
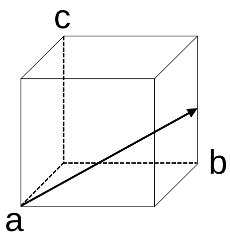
Q.48	Aliovalent doping of $MgCl_2$ in $NaCl$ leads to the formation of defects. Which one of the following is the correct defect reaction?
(A)	$Mg^{\bullet}_{Cl} + Na_{Na} + V'_{Cl} = \emptyset$
(B)	$Mg^{\bullet}_{Na} + Cl_{cl} + V'_{Na} = \emptyset$
(C)	$Mg_{Na} + Cl_{Cl} = \emptyset$
(D)	$Mg'_{Na} + Cl_{Cl} + V^{\bullet}_{Na} = \emptyset$
Q.49	A screw dislocation in a FCC crystal has Burgers vector of $\frac{a}{2}[110]$, where a is the lattice constant. The possible slip plane(s) is/are:
(A)	$(11\bar{1})$
(B)	(111)
(C)	$(\bar{1}11)$
(D)	$(1\bar{1}1)$

Q.50	The tensile true stress (σ) – true strain (ϵ) curve follows the Hollomon equation: $$\sigma = 500\epsilon^{0.15}\ \text{MPa}$$ At the maximum load, the work-hardening rate $\left(\frac{d\sigma}{d\epsilon}\right)$ is (in MPa): ________________ (rounded off to nearest integer)
Q.51	A metal has a certain vacancy fraction at a temperature of 600 K. On increasing the temperature to 900 K, the vacancy fraction increases by a factor of _______________ (rounded off to one decimal place) Given: Gas constant, $\mathrm{R} = 8.31\ \mathrm{J\ mol^{-1}K^{-1}}$ and activation energy for vacancy formation, $\mathrm{Q} = 68\ \mathrm{kJ\ mol^{-1}}$
Q.52	In a semiconductor, the ratio of electronic mobility to hole mobility is 10. The density of electrons and holes are $10^{15}\ m^{-3}$ and $10^{16}\ m^{-3}$, respectively. If the conductivity of the material is $1.6\ \Omega^{-1}\ m^{-1}$, then the mobility of holes is (in $m^2V^{-1}s^{-1}$) : _____________ (rounded off to nearest integer) Given: Charge of an electron: $1.6\ \times\ 10^{-19}\ C$

XH-C: Q.53 – Q.65 Carry TWO marks Each

Q.53	A student performed X-ray diffraction experiment on a FCC polycrystalline pure metal. The following $sin^2\,\theta$ values were calculated from the diffraction peaks. $sin^2\,\theta = 0.136,\ 0.185,\ 0.504,\ 0.544$ However, the student was negligent and missed noting one of the peaks. Which one of the following Miller indices corresponds to the missing peak?
(A)	(200)
(B)	(220)
(C)	(311)
(D)	(222)

Q.54 Match the lattice planes and directions (in Column I) with the corresponding Miller indices (in Column II):

Column I		Column II
(P)		1. $(\bar{1}11)$
(Q)		2. $[\bar{1}12]$
(R)		3. $[\bar{2}21]$
(S)		4. $(\bar{1}10)$

(A) P-2, Q-4, R-1, S-3

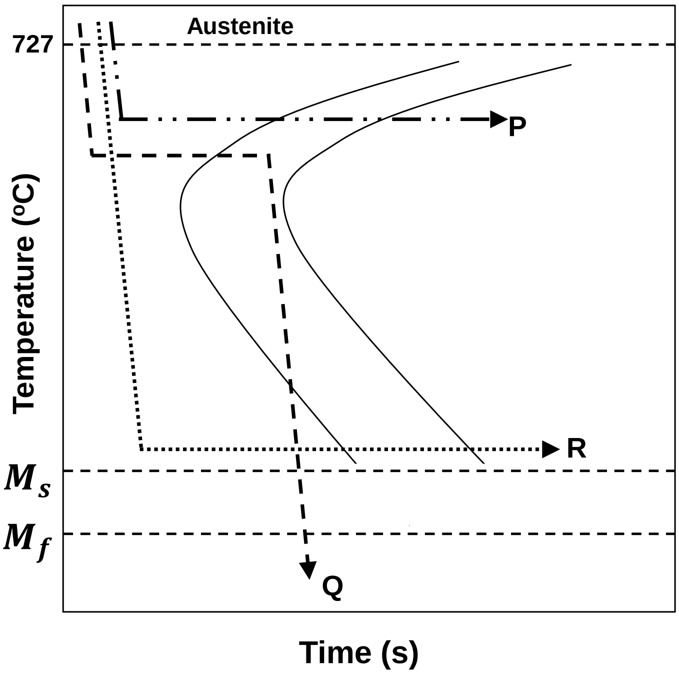
(B) P-3, Q-1, R-4, S-2

(C) P-2, Q-4, R-3, S-1

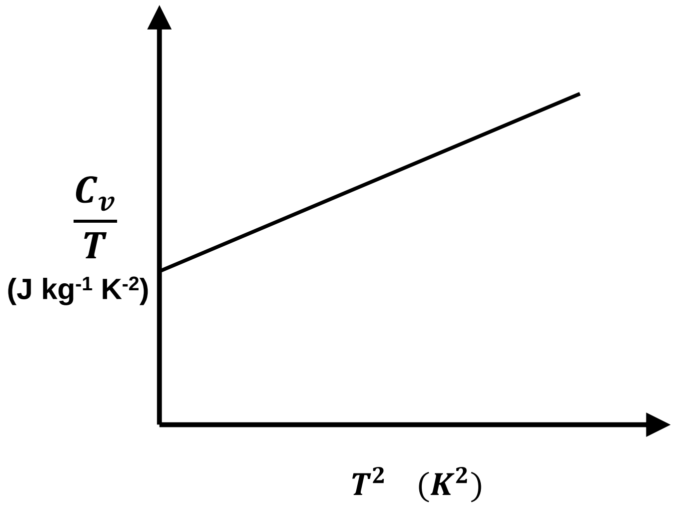
(D) P-3, Q-4, R-2, S-1

Q.55	Match the hardness test (in Column I) with its indenter type (in Column II).
	Column I — **Column II** (P) Brinell — 1. Diamond pyramidal (Q) Rockwell — 2. Diamond cone (R) Vickers — 3. Tungsten carbide sphere 4. Steel sphere
(A)	P-2, Q-4, R-1
(B)	P-4, Q-2, R-3
(C)	P-3, Q-4, R-2
(D)	P-4, Q-2, R-1

Column I	Column II
(P) Brinell	1. Diamond pyramidal
(Q) Rockwell	2. Diamond cone
(R) Vickers	3. Tungsten carbide sphere
	4. Steel sphere

Q.56	TTT diagram of a eutectoid steel is shown below. Match the heat treatment cycle (in Column I) with its microstructure (in Column II).
	
	Column I — **Column II** P — 1. Bainite only Q — 2. Pearlite only R — 3. Pearlite + Bainite + Martensite 4. Pearlite + Martensite
(A)	P-1, Q-2, R-4
(B)	P-2, Q-3, R-2
(C)	P-2, Q-4, R-1
(D)	P-2, Q-3, R-1

Q.57	Which of the following statement(s) is/are true for an optical microscope?
(A)	Increasing the aperture of the objective lens deteriorates the resolution
(B)	Reducing the wavelength of illuminating light improves the resolution
(C)	Increasing the refractive index of the medium in between the sample and the objective lens improves the resolution
(D)	Reducing the wavelength of illuminating light decreases the depth of field
Q.58	Among the 14 Bravais lattices, there is no base centred cubic unit cell. Which of the following statement(s) is/are true?
(A)	The base-centred cubic unit cell is same as the simple tetragonal unit cell
(B)	The base-centred cubic unit cell is same as the body centred tetragonal unit cell
(C)	The base-centred cubic unit cell is same as the simple orthorhombic unit cell
(D)	The base-centred cubic unit cell does not have any 3-fold rotation axis

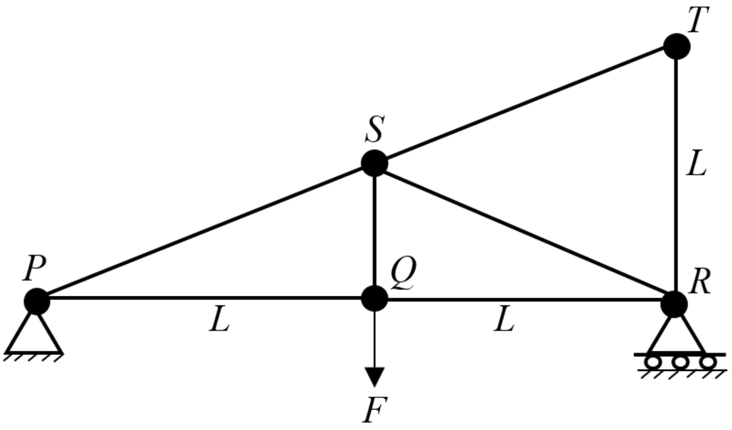
Q.59	Specific heat (C_v) of a material was found to depend on temperature as shown below. Which of the following statement(s) is/are true?
	
(A)	The material is metallic
(B)	The material is insulating
(C)	The material is three dimensional
(D)	The material is one dimensional
Q.60	A pure Silicon wafer is doped with Boron by exposing it to B_2O_3 vapour at an elevated temperature. It takes 1000 seconds to reach a Boron concentration of 10^{20} $atoms\ m^{-3}$ at a depth of 1 µm. The time taken to reach the same concentration of Boron at a depth of 2 µm is (in seconds): __________ (rounded off to nearest integer) Given: Boron concentration on the wafer surface remains constant.
Q.61	The Young's modulus of a quartz piezoelectric crystal is 100 GPa. The uniaxial stress required to change its polarization by 1% is (give absolute value in GPa) __________ (rounded off to nearest integer)

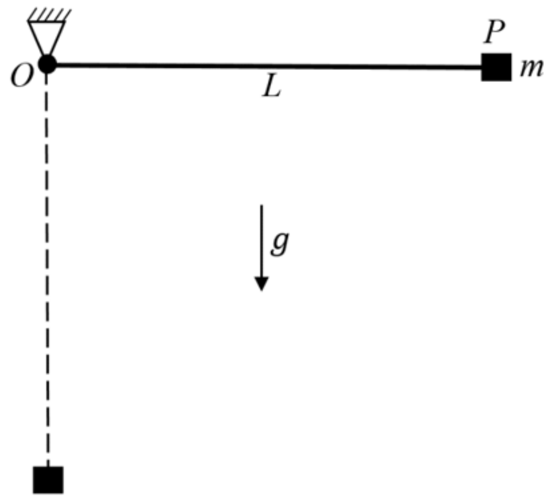
Q.62	A one-dimensional nanowire has a linear electron density of 10^8 $electrons\ cm^{-1}$. The Fermi energy of the system is (in eV) ______ (rounded off to two decimal places) Given: $\frac{\hbar^2}{2m} = 0.24\ (\text{eV})^2\ \text{s}^2\ \text{kg}^{-1}$ where 'm' is the mass of an electron
Q.63	Two moles of a monoatomic ideal gas at 10 atm and 300 K is expanded isothermally and reversibly to a pressure of 2 atm. The absolute value of work done by the system is (in kJ) ____________ (rounded off to two decimal places) Given: R = 8.31 J $\text{mol}^{-1}\text{K}^{-1}$, 1 atm = 101 kPa
Q.64	An electrochemical cell consists of pure Zn electrode (anode) and a hydrogen electrode (cathode) in a dilute Zn^{+2} solution. The overall reaction is: $Zn\ (s) + 2H^+ = H_2 + Zn^{+2}$ If the overall cell potential is +0.690 V, then the value of $ln\frac{[Zn^{+2}]}{[H^+]^2}$ is ________ (rounded off to two decimal places) Given: Pressure of hydrogen gas = 1 atm; Temperature = 298 K; $\frac{RT}{F} = 0.0256$ V, where R is gas constant and F is Faraday constant The standard reduction potential of: $Zn^{+2} + 2e = Zn$ ($E^o = -0.762$ V) versus Standard Hydrogen Electrode $2H^+ + 2e = H_2$ ($E^o = 0$ V)

Q.65	In a Raman spectroscopy experiment done at 300 K, a Raman line is observed at $200\ cm^{-1}$ ($\sim 25\ meV$). The ratio of the intensity of the Stokes line to that of the Anti-Stokes line is ____________ (rounded off to two decimal places) Given: Boltzmann constant, $k = 8.62 \times 10^{-5}\ eV\ K^{-1}$

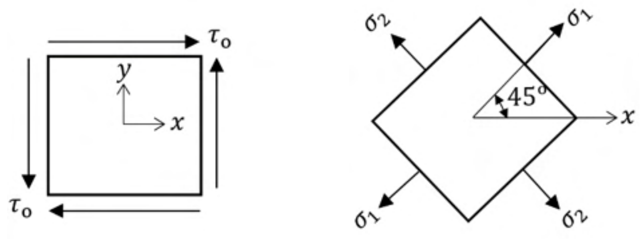
Solid Mechanics (XE-D)

XE-D: Q.66 – Q.74 Carry ONE mark Each

Q.66	A plane truss is simply supported at P and R as shown. A downward force F is applied at hinge Q. The axial force developed in member PS is
	
(A)	$\frac{\sqrt{5}}{2}$ F Tensile
(B)	$\frac{\sqrt{5}}{2}$ F Compressive
(C)	$\sqrt{5}\,F$ Tensile
(D)	$\sqrt{5}\,F$ Compressive

Q.67	A massless rigid rod *OP* of length *L* is hinged frictionlessly at *O*. A concentrated mass *m* is attached to end *P* of the rod. Initially, the rod *OP* is horizontal. Then, it is released from rest. There is gravity as shown. The rod acquires an angular velocity as it swings. The clockwise angular velocity of the rod, when it first reaches the vertical position as shown, is
	
(A)	$2\sqrt{\frac{g}{L}}$
(B)	$\sqrt{\frac{2g}{L}}$
(C)	$\sqrt{\frac{g}{L}}$
(D)	$\frac{1}{2}\sqrt{\frac{g}{L}}$

Q.68 Two equivalent descriptions of the state of stress at a point are shown in the figure. The normal stresses σ_1 and σ_2 as shown on the right must be, respectively,



(A) τ_o and $-\tau_o$

(B) $-\tau_o$ and τ_o

(C) $\frac{\tau_o}{\sqrt{2}}$ and $-\frac{\tau_o}{\sqrt{2}}$

(D) $-\frac{\tau_o}{\sqrt{2}}$ and $\frac{\tau_o}{\sqrt{2}}$

Q.69 The state of strain at a point in a machine component is given as

$\varepsilon_{xx} = 2.5 \times 10^{-4}$, $\varepsilon_{yy} = 2.0 \times 10^{-4}$, $\varepsilon_{zz} = -1.5 \times 10^{-4}$, $\varepsilon_{xy} = 2.5 \times 10^{-4}$,

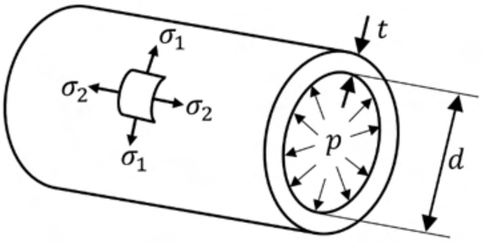
$\varepsilon_{yz} = -0.5 \times 10^{-4}$, $\varepsilon_{zx} = -1.0 \times 10^{-4}$. The volumetric strain at this point is

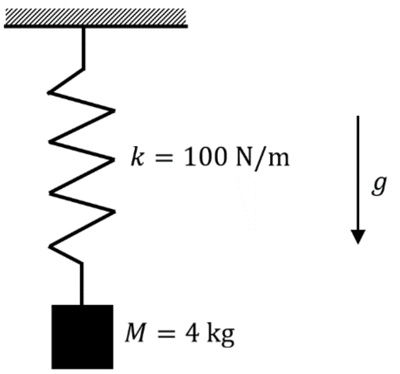
(A) 4×10^{-4}

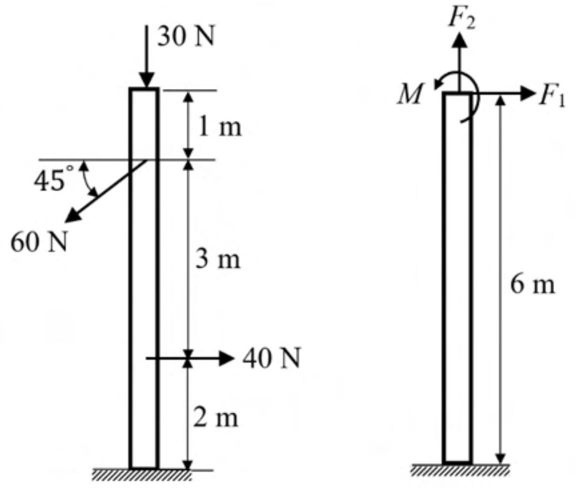
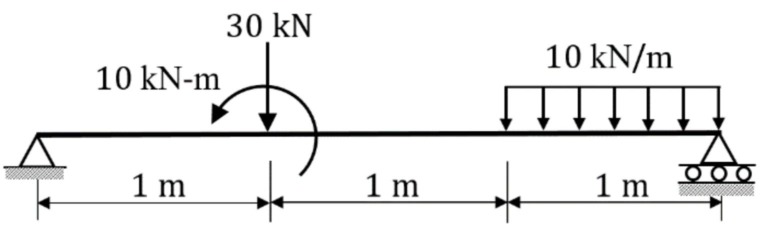
(B) 3×10^{-4}

(C) -5×10^{-4}

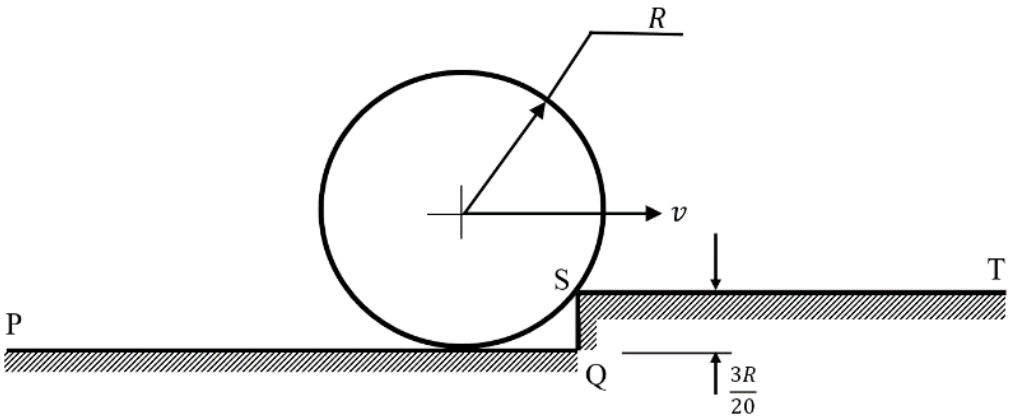
(D) -3×10^{-4}

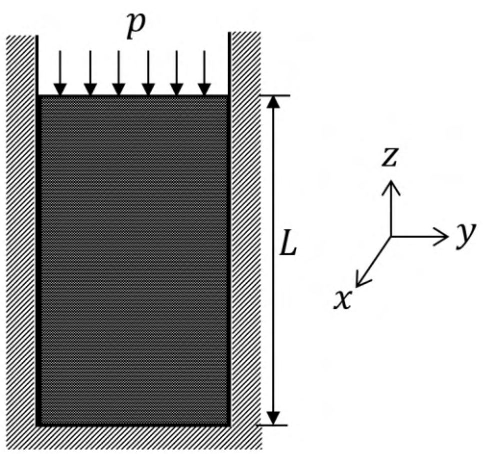
Q.70	A thin walled, closed cylindrical vessel of inside diameter d and wall thickness t contains a fluid under pressure p. The figure below shows a part of the cylindrical vessel; end caps are not shown. Consider the small element shown with sides parallel and perpendicular to the axis of the cylinder. The stresses σ_1 and σ_2 are
	
(A)	$\sigma_1 = \frac{pd}{2t}$; $\sigma_2 = \frac{pd}{4t}$
(B)	$\sigma_1 = \frac{pd}{t}$; $\sigma_2 = \frac{pd}{2t}$
(C)	$\sigma_1 = \frac{pd}{4t}$; $\sigma_2 = \frac{pd}{2t}$
(D)	$\sigma_1 = \frac{pd}{2t}$; $\sigma_2 = 0$

Q.71	A spring mass system is shown in the figure below. Take the acceleration due to gravity as g = 9.81 m/s^2. The static deflection due to weight and the time period of oscillations, respectively, are
	
(A)	0.392 m and 1.26 s
(B)	0.392 m and 3.52 s
(C)	0.626 m and 1.26 s
(D)	0.626 m and 3.52 s

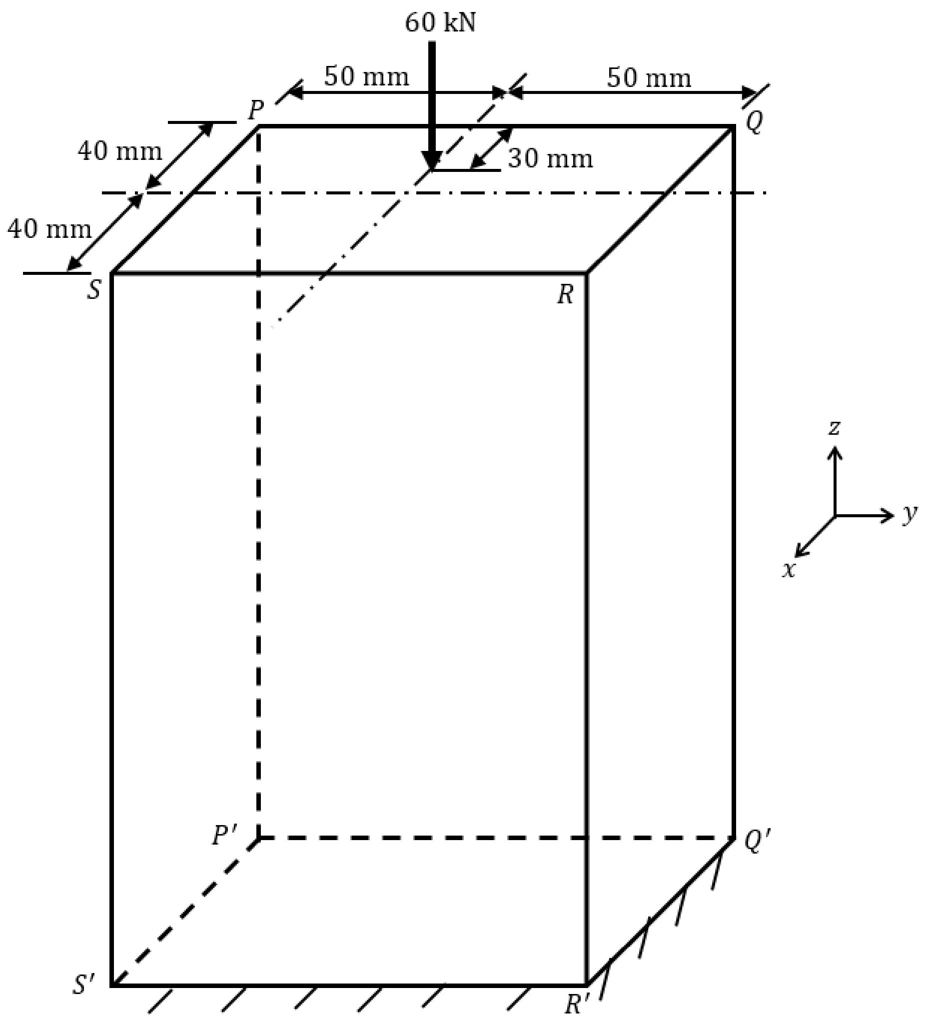
Q.72	A rod is subjected to three forces as shown in the figure on the left. An equivalent force system with forces F_1, F_2 and moment M is shown in the figure on the right. The value of M (in N-m) is______(rounded off to one decimal place).
	
Q.73	A simply supported beam of length 3 m is loaded as shown in the figure. The magnitude of the shear force (in kN) at the mid-point of the beam is______(rounded off to one decimal place).
	
Q.74	For a plane stress problem, the principal stresses are 100 MPa and 50 MPa. The magnitude of maximum shear stress (in MPa) in the material is______(rounded off to one decimal place).

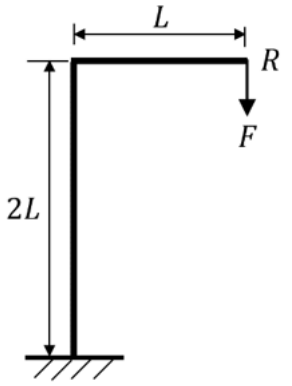
XE-D: Q.75 – Q.87 Carry TWO marks Each

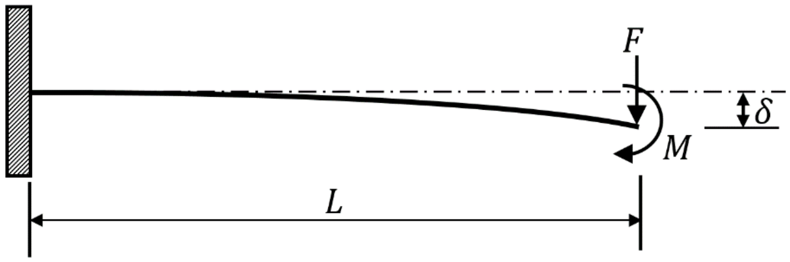
Q.75	A solid uniform rigid disk of mass m and radius R rolls without slipping along a horizontal surface PQ. The speed of the center of the disk is v. The disk then strikes a hurdle of height $\frac{3R}{20}$ at point S. During the impact, there is no rebound or slip at S and no impulse from the surface PQ. The magnitude of the velocity of the center of the disk immediately after the impact is
	
(A)	$0.1v$
(B)	$0.3v$
(C)	$0.7v$
(D)	$0.9v$

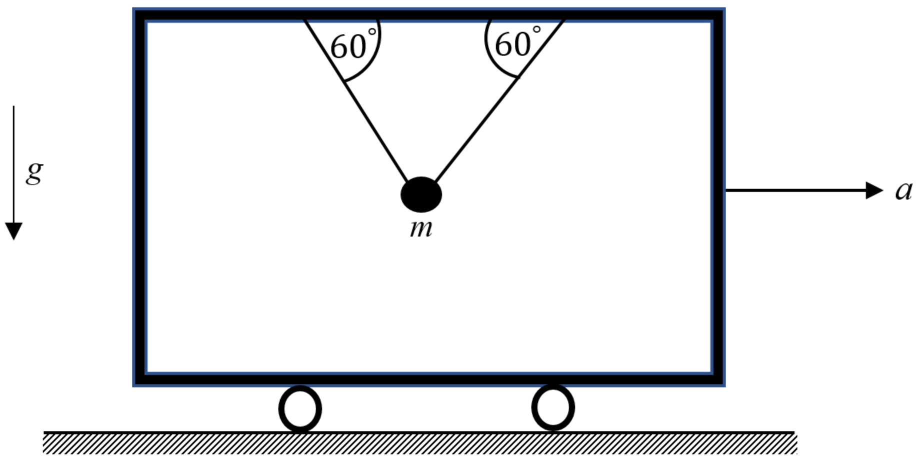
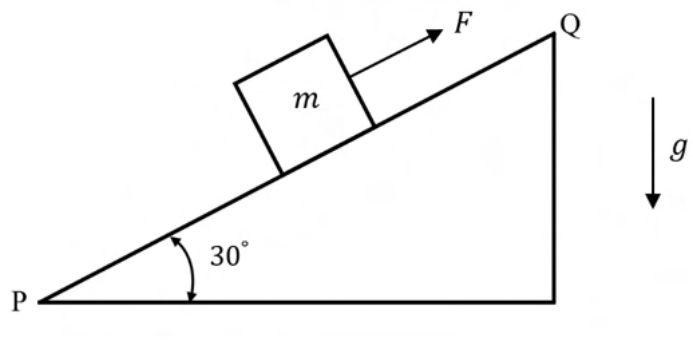
Q.76	A cylinder made of rubber (length = L and diameter = d) is inserted in a rigid container as shown in the figure. The rubber cylinder fits snugly in the rigid container. There is no wall friction. The modulus of elasticity of the rubber is E and its Poisson's ratio is ν. The cylinder is subjected to a small uniform pressure p as shown in the figure. The resulting axial strain (ε_{zz}) is
	
(A)	$-\frac{p}{E}$
(B)	$-\frac{p}{E}(1-2\nu)$
(C)	$-\frac{p}{E}\left[\frac{(1+\nu)(1-2\nu)}{(1-\nu)}\right]$
(D)	$-\frac{p}{E}\left[\frac{(1-\nu)(1-2\nu)}{(1+\nu)}\right]$

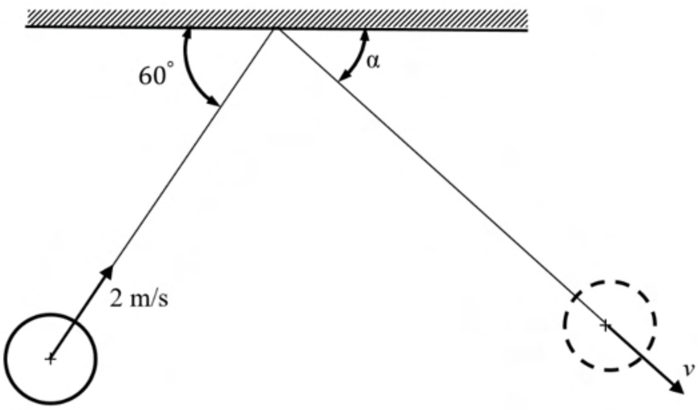
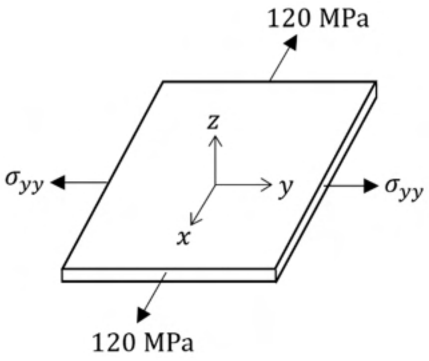
Q.77	The state of stress at the critical location in a structure is σ_{xx} = 420 MPa, σ_{yy} = 100 MPa, $\sigma_{zz} = \sigma_{xy} = \sigma_{yz} = \sigma_{zx} = 0$. The yield stress of the material in uniaxial tension is 400 MPa. Select the correct statement among the following.
(A)	The structure is safe by both Tresca (maximum shear stress) theory and von-Mises (distortion energy) theory.
(B)	The structure is safe by Tresca (maximum shear stress) theory and unsafe by von-Mises (distortion energy) theory.
(C)	The structure is unsafe by Tresca (maximum shear stress) theory and safe by von-Mises (distortion energy) theory.
(D)	The structure is unsafe by both Tresca (maximum shear stress) theory and von-Mises (distortion energy) theory.

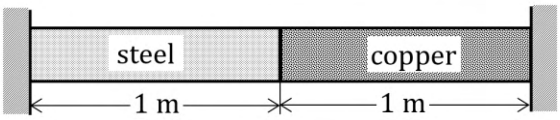
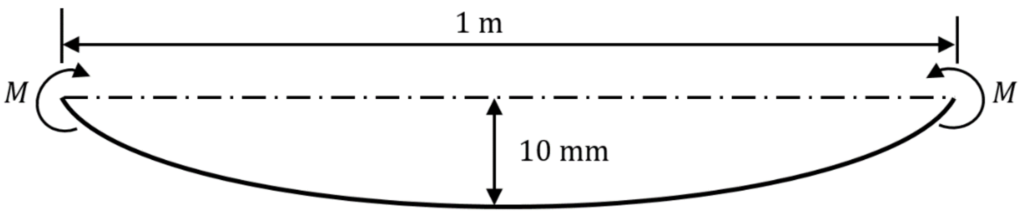
Q.78	The figure shows a column of rectangular cross section $100\ \text{mm} \times 80\ \text{mm}$. It carries a load of 60 kN at a point 30 mm from the edge PQ. The values of stress component σ_{zz} on surfaces $PQQ'P'$ and $SRR'S'$, at points far away from both ends of the column, are respectively
	
(A)	$18.75\ \text{N/mm}^2$ (Compressive) and $3.75\ \text{N/mm}^2$ (Tensile)
(B)	$18.75\ \text{N/mm}^2$ (Compressive) and $3.75\ \text{N/mm}^2$ (Compressive)
(C)	$13.13\ \text{N/mm}^2$ (Compressive) and $1.88\ \text{N/mm}^2$ (Tensile)
(D)	$13.13\ \text{N/mm}^2$ (Compressive) and $1.88\ \text{N/mm}^2$ (Compressive)

Q.79	Consider an electric pole with dimensions as shown in the figure. Let the end *R* be subjected to a vertical force *F*. The flexural rigidity of both vertical and horizontal bars is *EI*. Neglect the axial deflection of the vertical bar, and all effects of self-weight. The vertical deflection at end *R* is
	
(A)	$\dfrac{7FL^3}{3EI}$
(B)	$\dfrac{10FL^3}{3EI}$
(C)	$\dfrac{5FL^3}{3EI}$
(D)	$\dfrac{8FL^3}{3EI}$

Q.80	A uniform cantilever beam has flexural rigidity EI and length L. It is subjected to a concentrated force F and moment $M = 2FL$ at the free end as shown. The deflection (δ) at the free end is
	
(A)	$\frac{11FL^3}{12EI}$
(B)	$\frac{8FL^3}{9EI}$
(C)	$\frac{4FL^3}{3EI}$
(D)	$\frac{7FL^3}{6EI}$

Q.81	A steel ball of mass m = 10 kg is suspended from the ceiling of a moving carriage by two inextensible strings making 60° with the horizontal as shown. The carriage has an acceleration a such that the tension in the string on the right is double the tension in the string on the left. Take the acceleration due to gravity (g) as 10 m/s^2. The acceleration a (in m/s^2) is______(rounded off to one decimal place).
	
Q.82	A block of mass $m = 10$ kg is lying on an inclined plane PQ. The mass is restrained from sliding down the inclined plane by a force F. The coefficient of friction between the block and the inclined plane is 0.3. Take the acceleration due to gravity as 10 m/s^2. The smallest force F (in N) required to prevent the block from sliding down is______(rounded off to one decimal place).
	

Q.83	A spherical rigid ball of mass 10 kg is moving with a speed of 2 m/s in the direction shown. The ball collides with a rigid frictionless wall and rebounds at an angle α with a speed of v, as shown. The coefficient of restitution is 0.9. The angle α (in degrees) is______(rounded off to one decimal place).
	
Q.84	A thin steel plate is loaded in the x-y plane as shown in the figure. Take the Poisson's ratio of steel to be 0.3 and the modulus of elasticity of steel to be 200 GPa. The strain along the z-direction is $\varepsilon_{zz} = -3 \times 10^{-4}$. The value of σ_{yy} (in MPa) is______(rounded off to one decimal place).
	

Q.85	A composite rod made of steel and copper is fixed immovably at its ends as shown in the figure. The length of each portion of the rod is 1 m as shown. The cross-sections of both portions are the same. The moduli of elasticity of steel and copper are 200 GPa and 100 GPa, respectively. The coefficients of thermal expansion of steel and copper are 12×10^{-6} /°C and 18×10^{-6} /°C, respectively. The composite rod is initially stress free. Then, the temperature of the composite rod is increased by 100 °C. The magnitude of axial stress (in MPa) developed in the steel rod is______(rounded off to one decimal place).
	
Q.86	A slender uniform elastic rod of length 1 m and of solid circular cross-section of diameter 50 mm is originally straight. It is then loaded by equal and opposite end moments as indicated in the figure. The resulting lateral displacement of the mid-point of the rod is 10 mm (displacements are exaggerated in the figure). The maximum longitudinal strain in the rod is $p \times 10^{-3}$, where p is______(rounded off to one decimal place).
	
Q.87	Consider a solid cylindrical shaft and a hollow cylindrical shaft. Both shafts are axisymmetric and elastic, and have the same cross-sectional area. The hollow shaft has an outside diameter of 150 mm and an inside diameter of 120 mm. When both the shafts are twisted by the same twisting moment, the ratio of maximum shear stress developed in the hollow shaft (τ_h) to maximum shear stress developed in the solid shaft (τ_s) will be______(rounded off to three decimal places).

Thermodynamics (XE-E)

Q.88 – Q.96 Carry ONE mark Each

Q.88	**A** The number of properties required to fix the state of a system is given by 'state postulate'. **R** The state of a simple compressible system is completely specified by two independent, intensive properties. About the statements **A** and **R** applied to a single-phase system,
(A)	**A** is correct and **R** is incorrect.
(B)	**A** is incorrect and **R** is correct.
(C)	Both **A** and **R** are incorrect.
(D)	Both **A** and **R** are correct.
Q.89	Which of the following is an extensive property of a system?
(A)	Density
(B)	Pressure
(C)	Temperature
(D)	Total mass

Q.90	A tank of volume V contains homogeneous mixture of two ideal gases, A and B at a temperature T and a pressure P. The mixture contains n_A moles of gas A and n_B moles of gas B. If P_A and P_B are the partial pressures of gas A and gas B, respectively, then
(A)	$P_A = \frac{n_A}{n_A + n_B} P, \quad P_B = \frac{n_B}{n_A + n_B} P$
(B)	$P_A = \frac{n_B}{n_A} P, \quad P_B = \frac{n_A}{n_B} P$
(C)	$P_A = \frac{n_A}{n_B} P, \quad P_B = \frac{n_B}{n_A} P$
(D)	$P_A = \frac{n_B}{n_A + n_B} P, \quad P_B = \frac{n_A}{n_A + n_B} P$
Q.91	If an ideal air-standard Otto cycle and an ideal air-standard Diesel cycle operate on the same compression ratio, then the relation between the thermal efficiencies (η_{th}) of the cycles is
(A)	$\eta_{th,Otto} = \eta_{th,Diesel}$ and $\eta_{th,Otto} < 1$
(B)	$\eta_{th,Otto} > \eta_{th,Diesel}$
(C)	$\eta_{th,Otto} < \eta_{th,Diesel}$
(D)	$\eta_{th,Otto} = \eta_{th,Diesel} = 1$

Q.92	The following statements are given: (i) The third law of thermodynamics deals with the entropy of a substance at the absolute zero temperature. (ii) Entropy of any non-crystalline structure is zero at absolute zero temperature. (iii) At the absolute zero temperature, the crystal structure has maximum degree of order. (iv) The thermal energy of the substance at absolute zero temperature is maximum. The correct option describing these statements is
(A)	Only (i) is correct
(B)	Only (ii) is correct
(C)	Both (i) and (iii) are correct
(D)	Both (i) and (iv) are correct

Q.93	Adiabatic bulk modulus of a substance is defined as
(A)	$-\frac{1}{v}\left(\frac{\partial v}{\partial P}\right)_T$
(B)	$-v\left(\frac{\partial P}{\partial v}\right)_T$
(C)	$-\frac{1}{v}\left(\frac{\partial v}{\partial P}\right)_s$
(D)	$-v\left(\frac{\partial P}{\partial v}\right)_s$
Q.94	An insulated rigid closed tank of 2 m^3 internal volume contains saturated liquid-vapor mixture of water at 200 °C. The quality of the mixture is 0.75. The mass of the mixture in the tank is ____________ kg (*rounded off to one decimal place*). Use the following data for water: At 200 °C: v_f = 0.001156 m^3/kg, v_{fg} = 0.12620 m^3/kg, v_g = 0.12736 m^3/kg
Q.95	A rigid closed tank contains 2 kg of an ideal gas at 500 kPa and 350 K. A valve is opened, and half of the mass of the gas is allowed to escape. Then the valve is closed. If the final pressure in the tank is 300 kPa, the final temperature in the tank is ____________ K (*in integer*).

Q.96	Air at 400 K and 200 kPa is heated at constant pressure to 600 K. Assuming that the internal energy is a function of temperature only, the magnitude of change in internal energy during this process is ____________ kJ/kmol (*rounded off to one decimal place*). Use the following data: Molar specific heat of air at constant volume: $\bar{c}_v$ (kJ/kmol-K) $= a + bT + cT^2$ where T is temperature in K, $a = 19.686$ kJ/kmol-K, $b = 0.002$ kJ/kmol-K^2 and $c = 0.5 \times 10^{-5}$ kJ/kmol-K^3.

XE-XE: Q.97 – Q.109 Carry TWO marks Each

Q.97	A rigid closed tank having a volume of 2 m^3 contains 0.1 m^3 of saturated liquid water and 1.9 m^3 of saturated water vapor at 100 kPa. Heat is transferred to the tank until the final tank pressure reaches 2 MPa. Following data for water is given: At 100 kPa: v_f = 0.001043 m^3/kg, v_g = 1.694 m^3/kg, u_f = 417.33 kJ/kg, u_g = 2506.06 kJ/kg At 2 MPa: v_f = 0.001177 m^3/kg, v_g = 0.09963 m^3/kg, u_f = 906.42 kJ/kg, u_g = 2600.26 kJ/kg The magnitude of heat transfer in this process is
(A)	34670 kJ
(B)	55842 kJ
(C)	67906 kJ
(D)	77470 kJ

Q.98	An ideal Diesel cycle has a compression ratio of 20 and cut-off ratio of 1.5. At the beginning of the compression stroke, air is at 100 kPa, 300 K. Use the cold-air-standard assumptions with property value c_p = 1.005 kJ/kg-K. Assume c_p / c_v = 1.4. For this cycle, the net work output per unit mass is
(A)	335 kJ/kg
(B)	395 kJ/kg
(C)	500 kJ/kg
(D)	165 kJ/kg
Q.99	A 5 kg metal block (c_p = 0.5 kJ/kg-K) at 373 K is submerged into 10 kg of water (c_p = 4.2 kJ/kg-K) at 293 K in an insulated rigid container without spilling. Assuming thermal equilibrium is reached, the approximate entropy change of the universe is
(A)	−0.565 kJ/K
(B)	0.073 kJ/K
(C)	0.642 kJ/K
(D)	0.963 kJ/K

Q.100 Match the following:

	Thermodynamic function/equation		Expression
A1	Helmholtz function (a)	**B1**	$\left(\frac{\mathrm{d}}{\mathrm{d}T}(\ln P)\right)_{sat} = \frac{h_g - h_f}{RT^2}$
A2	Gibbs function (g)	**B2**	$u - Ts$
A3	T-ds equation	**B3**	$\mathrm{d}u = T\mathrm{d}s - P\mathrm{d}v$
A4	Clapeyron-Clausius equation	**B4**	$h - Ts$

(A) A1→B2, A2→B4, A3→B1, A4→B3

(B) A1→B4, A2→B2, A3→B1, A4→B3

(C) A1→B2, A2→B4, A3→B3, A4→B1

(D) A1→B4, A2→B2, A3→B3, A4→B1

Q.101 A piston-cylinder device initially contains 1 m^3 of air at 200 kPa and 25 °C. Air expands at constant pressure while a heater of 250 W is switched on for 10 minutes. There is a heat loss of 4 kJ during this process. Assuming air as an ideal gas, the final temperature of air is ____________ °C (*rounded off to one decimal place*).

Use the following data for air: R = 0.287 kJ/kg-K, c_p = 1.005 kJ/kg-K

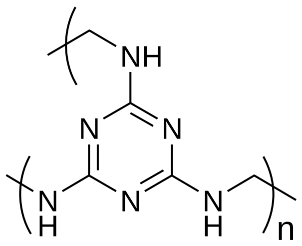
Q.102	Steam at 2 MPa and 300 °C steadily enters a nozzle of inlet diameter of 20 cm. Steam leaves the nozzle with a velocity of 300 m/s. The mass flow rate of steam through the nozzle is 10 kg/s. Assume no work interaction and no change in potential energy. If the heat loss from the nozzle per kg of steam is 3 kJ, the exit enthalpy per kg of steam is ____________ kJ (*rounded off to nearest integer*). Use the following data for steam: At 2 MPa and 300 °C: v = 0.12551 m^3/kg, h = 3024.2 kJ/kg
Q.103	A rigid tank of 2 m^3 internal volume contains 5 kg of water as a saturated liquid-vapor mixture at 400 kPa. Half of the mass of the saturated liquid in the tank is drained-off while maintaining constant pressure of 400 kPa in the tank. The final quality of the mixture remaining in the tank is ____________ (*rounded off to two decimal places*). Use the following data for water: At 400 kPa: v_f = 0.001084 m^3/kg, v_{fg} = 0.46138 m^3/kg, v_g = 0.46246 m^3/kg
Q.104	Consider a spark ignition engine which operates on an ideal air-standard Otto cycle. It uses a fuel which produces 44 MJ/kg of heat in the engine. If the engine requires 40 mg of fuel to produce 1 kJ of work output, then the compression ratio of the Otto cycle is ____________ (*rounded off to two decimal places*). For the entire cycle, use $c_p / c_v = 1.4$
Q.105	A refrigerator operates on an ideal vapor compression cycle between the pressure limits of 140 kPa and 800 kPa. The working fluid is the refrigerant R-134a. The refrigerant enters the compressor as saturated vapor at 140 kPa and exits at 800 kPa and 60 °C. It leaves the condenser as a saturated liquid at 800 kPa. The coefficient of performance (COP) of the refrigerator is ____________ (*rounded off to two decimal places*). Use the following property data for R-134a: At 140 kPa: h_f = 27.06 kJ/kg, h_g = 239.19 kJ/kg At 800 kPa: h_f = 95.48 kJ/kg, h_g = 267.34 kJ/kg At 800 kPa and 60 °C: h = 296.82 kJ/kg

Q.106	A steam power plant operates on a simple ideal Rankine cycle. The condenser pressure is 10 kPa and the boiler pressure is 5 MPa. The steam enters the turbine at 600 °C. Mass flow rate of the steam is 50 kg/s. Neglecting the pump work, the net power output of the plant is ____________ MW (*rounded off to one decimal place*). Use the following property data for water: At 10 kPa: h_f = 191.81 kJ/kg, h_{fg} = 2392.82 kJ/kg, h_g = 2584.63 kJ/kg s_f = 0.6492 kJ/kg-K, s_{fg} = 7.5010 kJ/kg-K, s_g = 8.1502 kJ/kg-K At 5 MPa and 600 °C: h = 3666.47 kJ/kg, s = 7.2588 kJ/kg-K
Q.107	In an air-conditioning system, air enters at 20 °C and 30% relative humidity at a steady rate of 30 m^3/min in a humidifier and it is conditioned to 25 °C and 60% relative humidity. Assuming entire process takes place at pressure of 100 kPa, the mass flow rate of the steam added to air in the humidifier is ____________ kg/min (*rounded off to three decimal places*). Use the following property data: At 20 °C and 25 °C, saturation pressures of water are 2.3392 kPa and 3.1698 kPa, respectively. For air, R = 0.287 kJ/kg-K
Q.108	An office uses a heat pump to receive 500 kJ/day heat in winter to maintain its temperature at 300 K. The ambient temperature is 280 K. If the COP of the heat pump is 60% of its theoretical maximum value, the ratio of actual work input to the minimum theoretical work input to the heat pump is ____________ (*rounded off to one decimal place*).
Q.109	In a liquid-vapour phase change process, $\left(\frac{\mathrm{d}P}{\mathrm{d}T}\right)_{sat}$ at 100 °C for saturated water is 3750 Pa/K. If the resulting change in specific volume $(v_g - v_f)$ is 1.672 m^3/kg, the enthalpy of vaporization (h_{fg}) will be ____________ kJ/kg (*in integer*).

Polymer Science and Engineering (XE-F)

XE-F: Q.110 – Q.118 Carry ONE mark Each

Q.110	Which one of the monomers given is used in the synthesis of cellulose?
(A)	Fructose
(B)	Lactic acid
(C)	Galactose
(D)	Glucose
Q.111	A copper wire upon loading instantaneously increases in length to l, and then continues to elongate gradually. Upon unloading, the wire retracts to length l. According to the Maxwell model, which one of the options given correctly relates the total strain E, the applied stress S, the modulus G, the material's resistance to flow η, and the elapsed time t between loading and unloading?
(A)	$E = (S/G) - (S/\eta)t$
(B)	$E = (S/G) \times (S/\eta)t$
(C)	$E = (S/G) + (S/\eta)t$
(D)	$E = (S/G) / (S/\eta)t$

Q.112	Consider the structure of a crosslinked polymer shown in the figure. From the options given, identify the monomers that are used in the synthesis of the polymer.
	
(A)	Melamine and Benzaldehyde
(B)	Melamine and Acetone
(C)	Melamine and Formaldehyde
(D)	Melamine and Ethanol

Q.113	Among the options given, choose the most suitable compatibilizer for blending Polyvinylidene fluoride (PVDF) and Acrylonitrile butadiene styrene (ABS).
(A)	Styrene-acrylonitrile (SAN)
(B)	Polybutadiene (PB)
(C)	Polymethyl methacrylate (PMMA)
(D)	Nylon 6

Q.114	A high molecular weight polymer passes through different zones from the hopper to the die in an extruder. Among the options given, identify the correct match between the zones and their key functions.

Zones		Key functions	
P	Metering zone	1	High shear forces for effective mixing
Q	Compression zone	2	Receives the charge or feed
R	Feed zone	3	Melts the charge or feed through heat conducted by the heating element
S	Working zone	4	The charge or feed acquires a constant flow rate imparted by the helical flight of the screw

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

Q.115	Polymer wetting is improved by the addition of fillers with functional groups. In a typical case-study, natural-clay was modified with hydroxyl groups and compounded with Nylon 6 along with an antioxidant. The resulting composite exhibited poor mechanical properties. Which one among the options given explains this observation?
(A)	The surface functional groups of the filler reacted with Nylon 6
(B)	The antioxidant degraded during the processing
(C)	The surface functional groups of the filler formed hydrogen bonds with the antioxidant
(D)	The antioxidant reacted with Nylon 6

Q.116	Among the options given, identify the correct match between the polymers and their glass transition temperatures (T_g).

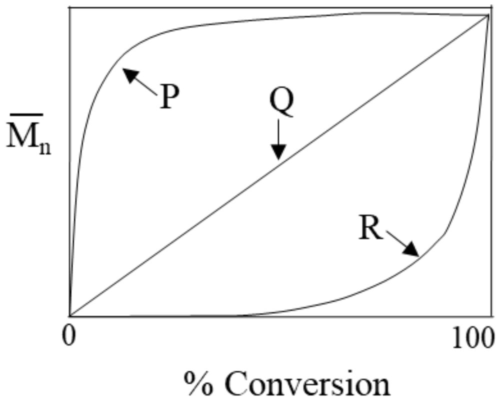
Polymer		**Glass transition temperature** (°C)	
P	High density polyethylene	1	>200
Q	Poly(vinyl carbazole)	2	145 to 155
R	Polymethyl methacrylate	3	-100 to -80
S	Polycarbonate	4	90 to 100

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

Q.117	What is the correct order of decreasing crystallinity of the given polymers?

P	atactic-Polypropylene
Q	syndiotactic-Polystyrene
R	Nylon 6
S	Polyethylene terephthalate

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

Q.118	Choose the correct option that best correlates the graphs with the polymerization methods.
	
(A)	P – living polymerization; Q – chain growth; R – step growth
(B)	P – chain growth; Q – living polymerization; R – step growth
(C)	P – step growth; Q – living polymerization; R – chain growth
(D)	P – living polymerization; Q – step growth; R – chain growth

XE-F: Q.119 – Q.131 Carry TWO marks Each

Q.119	From the options given, identify the correct match(es) between the polymer products with the most appropriate processing technique.

Polymer product		**Processing technique**	
P	Fishing rods	1	Compression moulding
Q	Soft drink bottles	2	Thermoforming
R	Plastic sheets	3	Pultrusion
S	Plastic trays	4	Blow moulding

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

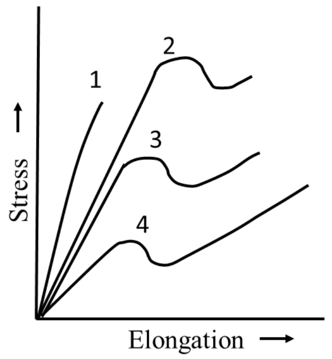
Q.120	Among the options given, which agents are used to vulcanize or cure rubbers?
(A)	Dicumyl peroxide
(B)	Zinc stearate
(C)	Carbon black
(D)	Dinitrobenzene

Q.121	Lipase is a natural enzyme, which cleaves carboxylic ester bonds. Among the options given, identify the polymer(s) degraded by lipase.
(A)	Polypropylene (PP)
(B)	Polycaprolactone (PCL)
(C)	Polyvinylidene fluoride (PVDF)
(D)	Polyethylene terephthalate (PET)
Q.122	Among the options given, identify the correct pair(s) of catalyst and co-catalyst that form a Ziegler-Natta catalyst.
(A)	$TiCl_3$ and $Al(CH_3CH_2)_2Cl$
(B)	$ZnCl_2$ and $Al(CH_3)_3$
(C)	TiO_2 and $Al(CH_3)_3$
(D)	VCl_4 and $Al(CH_3CH_2)_2Cl$

Q.123	Mechanical stress is applied on a polymer. Identify the correct match(es) between the statements (1, 2, 3, 4, 5) that describe the deformations and the regimes (P, Q, R).

P	Rubbery regime	1	Stress-relaxation takes place and the excess free energy is dissipated
Q	Region around glass transition temperature (T_g)	2	The motions of the molecules are long-range
R	Sample under deformed state	3	Segmental motion of the molecules is important
		4	The maximum relaxation time is strongly dependent on the molecular weight
		5	The deformations are independent of the molecular weight and primarily depend on the local structure

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

Q.124	Stress versus elongation profiles for different polymeric materials are shown in the figure. Choose the combination that best describes these profiles.
	
(A)	1-Nylon fibers; 2-Polyethylene; 3-Vulcanized rubber; 4-Polystyrene
(B)	1-Polyethylene; 2-Vulcanized rubber; 3-Polystyrene; 4-Nylon fibers
(C)	1-Polystyrene; 2-Nylon fibers; 3-Polyethylene; 4-Vulcanized rubber
(D)	1-Vulcanized rubber; 2-Polyethylene; 3-Nylon fibers; 4-Polystyrene
Q.125	Among the options given, which method(s) is/are used for the synthesis of atactic polystyrene?
(A)	Free radical polymerization
(B)	Ring opening polymerization
(C)	Polycondensation
(D)	Ionic polymerization

Q.126	A nylon sample of 0.03 m^2 cross-sectional area is subjected to a creep load of 10 kN. The load is removed after a duration of 60 s. Young's modulus and the viscosity for nylon are 1 GPa and 300 Giga Poise. The compliance of the specimen is ________$\times 10^{-9}$ m^2/N. *(Answer in integer)*
Q.127	Polyvinylidine fluoride (PVDF) was quenched from the melt in one case and in the other case, it was slowly cooled from the melt at 10 $^{\circ}$C/min. The percentage crystallinity of the slowly cooled PVDF is 60%. The heat of fusion for the quenched PVDF is $0.5\Delta H_m$ (ΔH_m is the heat of fusion for the slowly cooled PVDF), and the heat of fusion for 100% crystalline PVDF is 100 J/g. The percentage crystallinity of the quenched PVDF is ______%. *(Answer in integer)*
Q.128	A polymeric material of density 0.9 g/cc and melt volume of 10 cc in an extruder has a residence time of 100 s. The output of the extruder is _____ kg/h. *(Rounded off to two decimal places)*
Q.129	A polymer weighing 0.2 g is dissolved in 100 ml of benzene and has a relative viscosity of 1.5. The polymer obeys Mark-Houwink equation with constants a = 0.5 and K = 0.001. The molecular weight of the polymer is _____ $\times 10^{10}$ g/mol. (*Rounded off to two decimal places*)
Q.130	A continuous and aligned glass-fiber reinforced composite consists of 40 vol% of glass-fiber having a modulus of elasticity of 69 GPa and 60 vol% of a polyester resin, which when hardened, displays a modulus of 3.4 GPa. The modulus of elasticity of this composite in the longitudinal direction is___________GPa. *(Rounded off to two decimal places)*

Q.131 The molar mass distribution of a polymer is

Number of molecules	Molar mass (g/mol)
100	7500
50	5000

The resulting weight average molecular weight of the polymer is ________ g/mol.
(Answer in integer)

Food Technology (XE-G)

XE-G: Q.132 – Q.140 Carry ONE mark Each

Q.132	Choose the correct group of fat soluble vitamins
(A)	Cholecalciferol, α-Tocopherol, Menadione
(B)	Thiamine, Cholecalciferol, α-Tocopherol
(C)	Niacin, α-Tocopherol, Menadione
(D)	Biotin, Thiamin, Niacin
Q.133	The synthesis of thyroxine T4 in human body requires
(A)	Selenium
(B)	Iodine
(C)	Iron
(D)	Zinc

Q.134	Which among the followings is NOT an essential amino acid?
(A)	L-Phenylalanine
(B)	L-Valine
(C)	L-Lysine
(D)	L-Arginine
Q.135	The time required for stipulated destruction of a microbial population at a given temperature is
(A)	D-value
(B)	F-value
(C)	z-value
(D)	Q_{10} value

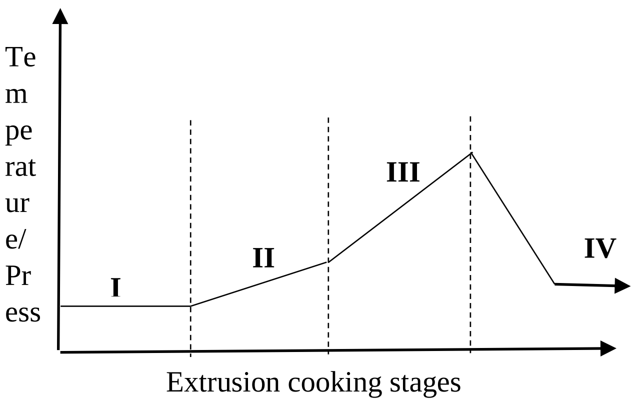
Q.136	Which among the following statements is NOT correct?
(A)	Cod fish is a major source of ω-3 fatty acids.
(B)	Beetroot is a good source of β-carotene.
(C)	Apple is a good source of vitamin B_{12}.
(D)	Fresh sugarcane juice is a good source of polyphenol oxidase.
Q.137	Which of the following statements is NOT correct?
(A)	As the shear rate increases, the apparent viscosity decreases for a pseudoplastic fluid.
(B)	As the shear rate increases, the apparent viscosity increases for a dilatant fluid.
(C)	A Bingham fluid requires application of yield stress prior to any response.
(D)	Rheopectic and thixotropic are two time independent fluids.

Q.138	Calculate the efficiency in percent (*rounded off to 1 decimal place*) of an oil expeller which yields 37 kg oil containing 5% solid impurities from 100 kg mustard seeds. The oil content of the mustard seed is 38%.
Q.139	Orange juice is packaged aseptically and stored under ambient conditions. The degradation of vitamin C in the juice occurs during storage and it follows first order reaction kinetics. The degradation rate constant is 5.2×10^{-3} day^{-1}. The half-life of vitamin C in days is ____________ (*in integer*).
Q.140	The weight of 10 kg dried cauliflower containing 5% moisture (wet basis) after rehydration is 60 kg. If the fresh cauliflower contained 87% moisture (wet basis), calculate the coefficient of rehydration (*rounded off to 2 decimal places*).

XE-G: Q.141 – Q.153 Carry TWO marks Each

Q.141	Match the industrial product in Column I with fermentative organism in Column II.
	Column I / Column II P. Vinegar — 1. *Enterbacter aerogenes* Q. Citric acid — 2. *Saccharomyces cerevisiae* R. Ethanol — 3. *Acetobacter aceti* S. L-Lysine — 4. *Aspergillus niger*
(A)	P-3, Q-4, R-2, S-1
(B)	P-1, Q-3, R-2, S-4
(C)	P-3, Q-1, R-4, S-2
(D)	P-2, Q-1, R-3, S-4

Q.142	Match the enzyme in Column I with its application in food processing/reaction given in Column II.
	Column I / **Column II** P. Chymosin — 1. Acyl glycerol restructuring Q. Thermolysin — 2. Lactose hydrolysis R. β-Galactosidase — 3. Aspartame synthesis S. Lipase — 4. Cheese manufacturing
(A)	P-4, Q-3, R-2, S-1
(B)	P-3, Q-1, R-2, S-4
(C)	P-4, Q-2, R-3, S-1
(D)	P-1, Q-4, R-2, S-3

Q.143	Identify the Gram +ve bacteria responsible for causing food borne diseases among the followings
(A)	*Campylobacter jejuni*
(B)	*Clostridium botulinum*
(C)	*Vibrio cholerae*
(D)	*Salmonella typhi*
Q.144	Extrusion cooking is accomplished in four different stages, which are indicated as I, II, III and IV in the figure given below. Choose the correct option representing the name of each stage.
	
(A)	I – Feeding, II – Cooking, III – Kneading, IV – Expansion
(B)	I – Kneading, II – Feeding, III – Cooking, IV – Expansion
(C)	I – Feeding, II – Kneading, III – Cooking, IV – Expansion
(D)	I – Cooking, II – Kneading, III – Feeding, IV – Expansion

Q.145	Match the method/ value used for measuring lipid characteristics in Column I with the corresponding properties indicated by them, in Column II.
	Column I / Column II P. Thiobarbituric acid test — 1. Induction time Q. Rancimat method — 2. Degree of unsaturation R. Peroxide value — 3. Carbonyl content S. Iodine value — 4. Hydroperoxide content
(A)	P-3, Q-1, R-4, S-2
(B)	P-1, Q-3, R-4, S-2
(C)	P-3, Q-1, R-2, S-4
(D)	P-3, Q-4, R-1, S-2

Column I		Column II	
P.	Thiobarbituric acid test	1.	Induction time
Q.	Rancimat method	2.	Degree of unsaturation
R.	Peroxide value	3.	Carbonyl content
S.	Iodine value	4.	Hydroperoxide content

Q.146	Match the peeling technique in Column I with the vegetable, for which it is used in industry, given in Column II.

	Column I		Column II
P.	Knife peeling	1.	Brinjal
Q.	Abrasion peeling	2.	Tomato
R.	Flame peeling	3.	Potato
S.	Flash peeling	4.	Cucumber

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

Q.147	Match the process in Column I with the related food component in Column II.
	Column I / Column II P. Caramelization — 1. Lipid Q. Denaturation — 2. Sugar R. Oxidation — 3. Pigment S. Bleaching — 4. Enzyme
(A)	P-2, Q-4, R-1, S-3
(B)	P-2, Q-1, R-4, S-3
(C)	P-1, Q-3, R-2, S-4
(D)	P-2, Q-1, R-3, S-4

Q.148	Identify the correct statement(s) related to grain polysaccharides among the followings.
(A)	Dextrin are a group of low molecular weight polysaccharides produced by dry hydrolysis of starch.
(B)	Amylose is a linear polymer of D-glucose units joined by α (1→6) glycoside linkages.
(C)	Amylopectin is a branched chain polymer of D-galactose monomer units.
(D)	Retrogradation is a process of reassociation of amylose and formation of crystalline structure by gelatinized starch upon cooling.
Q.149	Identify the correct pair(s) of governing law with respective process operation.
(A)	Stoke's law - Mass transfer
(B)	Kirchhoff's law - Radiation heat transfer
(C)	Fourier's law –Conduction heat transfer
(D)	Fick's law - Molecular diffusion
Q.150	A hammer mill is used to grind blackgram. The size distribution of the blackgram is such that 80% passes through a 6-mesh (particle size = 3.36 mm) screen. The power requirement to produce a powder, 80% of which passes through a 45-mesh (particle size = 0.354 mm) screen is 4.5 kW. The power in kW required to produce a finer powder 80% of which passes through a 60-mesh (particle size = 0.25 mm) will be ____________ (*rounded off to 2 decimal places*). Assume the feed rate to the mill is constant in both the cases. Use Bond's law of size reduction.

Q.151	If D_{10} for *Salmonella* in egg yolk is 0.75 kGy, calculate the radiation dose in kGy (*rounded off to 2 decimal places*) required for reducing the *Salmonella* count in egg yolk by 8 log cycles.
Q.152	The average moisture binding energy of a plant protein based snack at 8% moisture content (dry basis) is 3200 $cal.mol^{-1}$. If the water activity of the snack at the above moisture content is 0.30 at 30 °C, the water activity of the sample at 45 °C is ______________ (*rounded off to 2 decimal places*). The value of Gas constant R = 1.987 $cal.mol^{-1}.K^{-1}$.
Q.153	Cow milk is pasteurized at a flow rate of 1 $kg.s^{-1}$ in a counter-current heat exchanger using hot water as the heating medium. The milk enters the heat exchanger at 15 °C and exits at 50 °C. The specific heat of cow milk is 3.5 $kJ.kg^{-1}.°C^{-1}$ and remains constant at the inlet and exit of the heat exchanger. The inlet and exit temperatures of the hot water are 75 °C and 60 °C respectively. If the overall heat transfer coefficient is 1800 $W.m^{-2}.°C^{-1}$, the heat transfer surface area in m^2 is ______ (*rounded off to 2 decimal places*). Assume steady state conditions.

Atmospheric and Ocean Science (XE-H)

XE-H: Q.154 – Q.162 Carry ONE mark Each

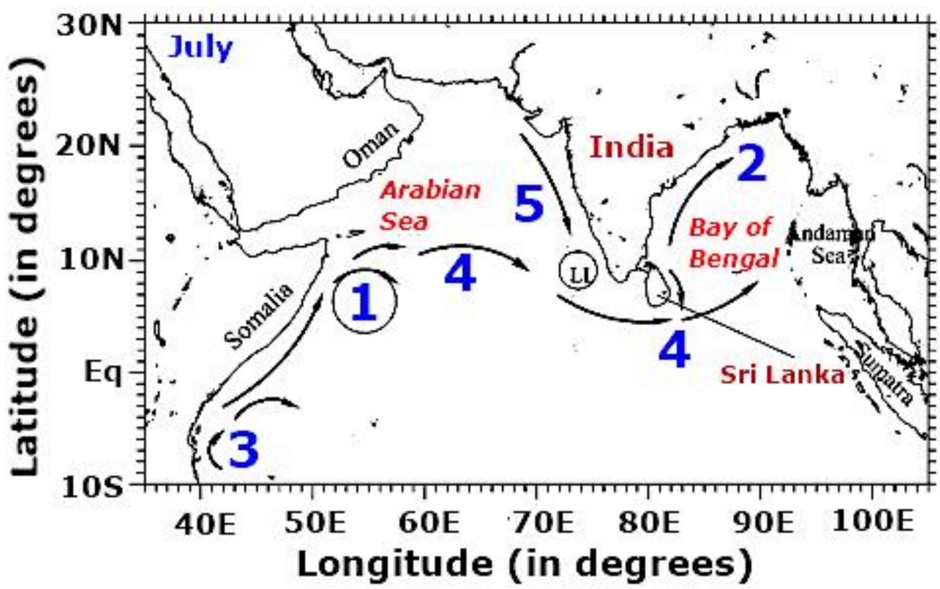
Q.154	The net water level elevation near the coast arising due to a tropical-cyclone-induced storm is a combination of the following factors __________.
(A)	astronomical tides, and distant cyclonic storm
(B)	wind-induced waves, astronomical tides, and distant cyclonic storm
(C)	astronomical tides, coastal currents, and distant cyclonic storm
(D)	riverine flow, astronomical tides, and distant cyclonic storm
Q.155	The typical speeds of a tsunami wave in water depths of 10 m, 100 m, and 1000 m, respectively, are _________.
(A)	approximately 100 m s^{-1}, 31 m s^{-1} and 10 m s^{-1}
(B)	approximately 50 m s^{-1}, 75 m s^{-1} and 100 m s^{-1}
(C)	approximately 10 m s^{-1}, 31 m s^{-1} and 100 m s^{-1}
(D)	approximately 100 m s^{-1}, 10 m s^{-1} and 31 m s^{-1}

Q.156	Which classification of tides best represents the west coast of India?
(A)	Diurnal and Mixed
(B)	Semidiurnal and Mixed
(C)	only Diurnal
(D)	only Mixed
Q.157	The variation in geostrophic winds with height, in particular, at the atmospheric boundary layer, considering the variation in pressure gradient as a function of height, is referred to as ___________.
(A)	Isallobaric winds
(B)	Gradient winds
(C)	Thermal winds
(D)	Cyclostrophic winds
Q.158	Consider the following options and pick out the right choice. The solubility of a gas in sea water increases with _________.
(A)	the increase of temperature, salinity and pressure
(B)	the decrease of temperature, salinity and pressure
(C)	the increase of temperature, and the decrease of salinity and pressure
(D)	the decrease of temperature and salinity, and the increase of pressure

Q.159	From the list given below, identify the organism type in the biological pump that takes up carbon dioxide from the atmosphere into the ocean.
(A)	Zooplankton
(B)	Fish
(C)	Phytoplankton
(D)	Radiolarians
Q.160	The amount of CO_2 that can be absorbed ________ when the temperature of seawater decreases.
(A)	Remains the same
(B)	Increases
(C)	Decreases
(D)	Can either increase or decrease
Q.161	Which among the following gases has the highest global warming potential?
(A)	CO_2
(B)	Water vapor
(C)	Methane
(D)	N_2O

Q.162	What will happen to the speed of a balanced flow as one moves across the isobar along a particular latitude?
(A)	The speed changes for a geostrophic flow and remains constant for a cyclostrophic flow
(B)	The speed remains constant for a geostrophic flow and changes for a cyclostrophic flow
(C)	The speed remains constant for both (geostrophic and cyclostrophic) types of flow
(D)	The speed changes for both (geostrophic and cyclostrophic) types of flow

XE-H: Q.163 – Q.175 Carry TWO marks Each

Q.163	The following illustration depicts the circulation pattern in the North Indian Ocean during the southwest (June-August) monsoon. Identify the markers numbered from 1-5 in the illustration and pick out the right choice.
	
(A)	1. Great Whirl, 2. East India Coastal Current, 3. East African Coastal Current, 4. Summer (Southwest) Monsoon Current, and 5. West India Coastal Current.
(B)	1. East African Coastal Current, 2. Summer (Southwest) Monsoon Current, 3. Great Whirl, 4. South Equatorial Counter Current, and 5. East India Coastal Current.
(C)	1. Great Whirl, 2. Summer (Southwest) Monsoon Current, 3. West India Coastal Current, 4. Somali Current, and 5. East India Coastal Current.
(D)	1. East African Coastal Current, 2. West India Coastal Current, 3. Somali Current, 4. East India Coastal Current, and 5. South Equatorial Counter Current.

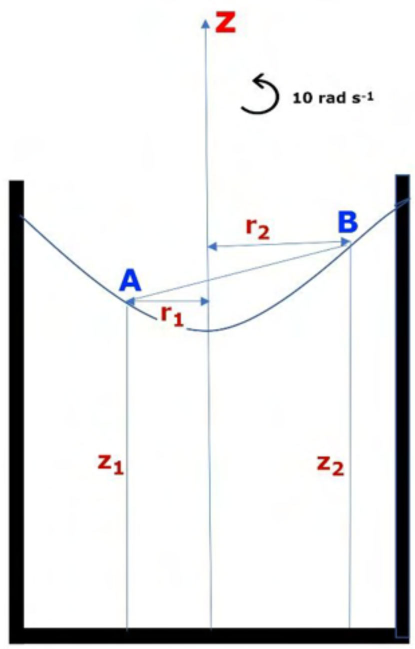
Q.164	From the following list identify the region that has low chlorophyll and low nutrients.
(A)	Upwelling, anticyclonic eddy
(B)	Upwelling, cyclonic eddy
(C)	Downwelling, anticyclonic eddy
(D)	Downwelling, cyclonic eddy
Q.165	Match the following physical phenomena from the perspective of monsoonal circulation:

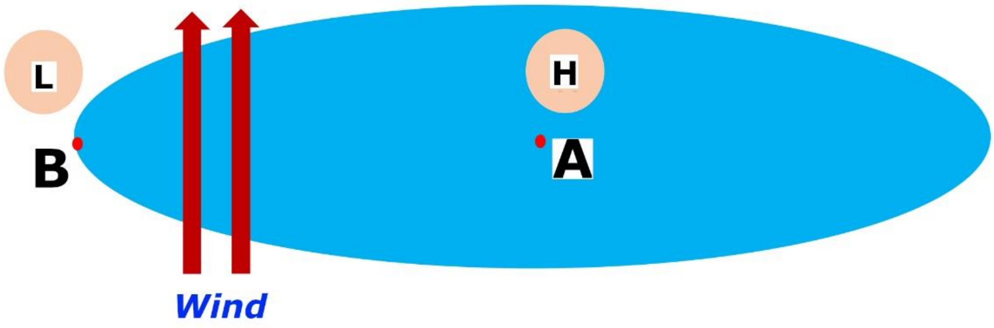
Column-1	Column-2
a) Reversal of East-West temperature gradient with seasons	i) Over the tropics
b) Reversal of North-South temperature gradient with seasons	ii) Indian Ocean
c) Surface cooling and deepening of mixed layer	iii) Over mid-latitudes
d) Northward movement of south equatorial current	iv) Arabian Sea

(A)	a-i, b-iii, c-ii, d-iv
(B)	a-iii, b-i, c-iv, d-ii
(C)	a-iii, b-ii, c-iv, d-i
(D)	a-ii, b-i, c-ii, d-iv

Q.166	Choose the correct statement(s) in context to Ekman spiral from the following:
(A)	The balance of Coriolis force and pressure
(B)	The balance of Coriolis force, wind shear, and frictional force
(C)	Deflection of surface current to the right of the wind direction in the Northern hemisphere
(D)	The increase of current velocity with depth
Q.167	Which of the following is/are associated with winter rainfall over India?
(A)	Northeast monsoon
(B)	Southwest monsoon
(C)	Western disturbances
(D)	Agulhas Current
Q.168	If the global albedo is increased from 0.3 to 0.4, the global radiative equilibrium temperature (in K) would decrease by ________. (consider no greenhouse effect, solar constant = 1360 W m^{-2} and Stefan-Boltzmann constant = 5.67×10^{-8} W m^{-2} K^{-4}, *rounded off to one decimal place*).

Q.169	When a parcel of dry air rises at a rate of 2 cm s^{-1} vertically, what should be the rate of heating per unit mass in J s^{-1} kg^{-1} (due to the radiation, conduction, etc.) in order to maintain the air parcel at a constant temperature? (consider the acceleration due to gravity as 9.8 m s^{-2}, *rounded off to three decimal places*).
Q.170	Two balls each of 5 cm in diameter are placed 200 m apart on a horizontal frictionless plane at 45° N. The balls are impulsively propelled directly at each other with equal speeds. What must be the speed in m s^{-1} so that the two balls just miss each other? (consider the value of Ω as 7.29×10^{-5} rad s^{-1}, *rounded off to two decimal places*).
Q.171	A parcel of dry air having an initial temperature of 30 °C at 1000 hPa level is lifted adiabatically. At what pressure (in hPa) its density reduces by half? (consider the ratio of the specific heat of dry air at a constant pressure to the specific heat of dry air at a constant volume, C_p/C_v = 0.71, *rounded off to two decimal places*).

Q.172	A cylindrical tank containing water is rotating about the z-axis at a constant angular velocity of 10 rad s^{-1}. The schematic of the isobaric surface is shown in the following illustration, where 'A' and 'B' are two points on the isobaric surface at heights 'z_1' and 'z_2', respectively. Assuming the atmospheric pressure to be negligible and no transient flow, estimate the elevation difference in m between 'z_1' and 'z_2'. (consider r_1 = 0.5 m, r_2 = 1.0 m and gravitational acceleration g = 9.8 m s^{-2}, *rounded off to two decimal places*)
	
Q.173	Consider that there are 295 million vehicles across India and they drive about 12000 km yr^{-1}. Each vehicle consumes about 25 km lit^{-1} of petrol and the amount of carbon released per litre is 5.5 gm. What is the amount of carbon emitted into the atmosphere in mega ton per year (*rounded off to two decimal places*)?
Q.174	Consider the two parallel isobars separated by a spacing of 250 km at 30º N (air density = 0.70 kg m^{-3}, $2\Omega = 14.6\times10^{-5}$ rad s^{-1}) with a pressure gradient of 5 hPa. Calculate the geostrophic velocity in m s^{-1} (*rounded off to two decimal places*).

Q.175	Considering a gyre system in the following illustration (where 'L' and 'H' represent low- and high-pressure regions along 45° N), the average slope between the points 'A' and 'B' is 2.1 cm km^{-1} under no wind condition. For a steady southerly wind of 10 m s^{-1} over these regions, find out the magnitude of the current velocity in m s^{-1} (*rounded off to two decimal places*).
	

END OF QUESTION PAPER