GATE 2022 Engineering Sciences XE

GATE 2022 General Aptitude

Q.1 – Q.5 Carry ONE mark each.

Q.1	The movie was funny and I _____.
(A)	could help laughing
(B)	couldn't help laughed
(C)	couldn't help laughing
(D)	could helped laughed

Q.2	$x : y : z = \frac{1}{2} : \frac{1}{3} : \frac{1}{4}$. What is the value of $\frac{x+z-y}{y}$?
(A)	0.75
(B)	1.25
(C)	2.25
(D)	3.25

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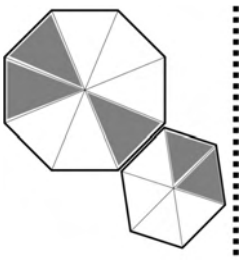
Q.3	Both the numerator and the denominator of $\frac{3}{4}$ are increased by a positive integer, x, and those of $\frac{15}{17}$ are decreased by the same integer. This operation results in the same value for both the fractions. What is the value of x?
(A)	1
(B)	2
(C)	3
(D)	4

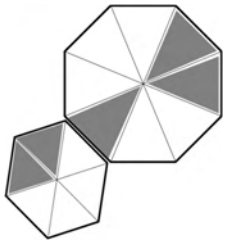
Q.4	A survey of 450 students about their subjects of interest resulted in the following outcome. • 150 students are interested in Mathematics. • 200 students are interested in Physics. • 175 students are interested in Chemistry. • 50 students are interested in Mathematics and Physics. • 60 students are interested in Physics and Chemistry. • 40 students are interested in Mathematics and Chemistry. • 30 students are interested in Mathematics, Physics and Chemistry. • Remaining students are interested in Humanities. Based on the above information, the number of students interested in Humanities is
(A)	10
(B)	30
(C)	40
(D)	45

Q.5

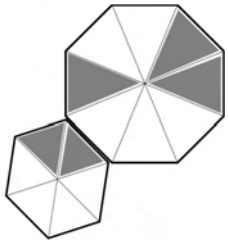


For the picture shown above, which one of the following is the correct picture representing reflection with respect to the mirror shown as the dotted line?

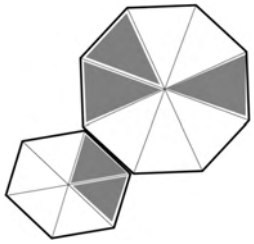
(A)



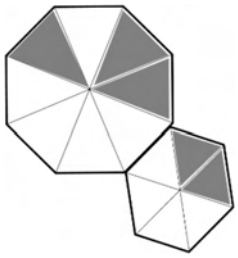
(B)



(C)



(D)



Q. 6 – Q. 10 Carry TWO marks each.

Q.6	In the last few years, several new shopping malls were opened in the city. The total number of visitors in the malls is impressive. However, the total revenue generated through sales in the shops in these malls is generally low. Which one of the following is the CORRECT logical inference based on the information in the above passage?
(A)	Fewer people are visiting the malls but spending more
(B)	More people are visiting the malls but not spending enough
(C)	More people are visiting the malls and spending more
(D)	Fewer people are visiting the malls and not spending enough

Q.7	In a partnership business the monthly investment by three friends for the first six months is in the ratio $3:4:5$. After six months, they had to increase their monthly investments by 10%, 15% and 20%, respectively, of their initial monthly investment. The new investment ratio was kept constant for the next six months. What is the ratio of their shares in the total profit (in the same order) at the end of the year such that the share is proportional to their individual total investment over the year?
(A)	22 : 23 : 24
(B)	22 : 33 : 50
(C)	33 : 46 : 60
(D)	63 : 86 : 110

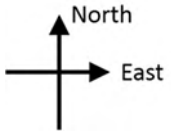
Q.8	Consider the following equations of straight lines: Line L1: $2x - 3y = 5$ Line L2: $3x + 2y = 8$ Line L3: $4x - 6y = 5$ Line L4: $6x - 9y = 6$ Which one among the following is the correct statement?
(A)	L1 is parallel to L2 and L1 is perpendicular to L3
(B)	L2 is parallel to L4 and L2 is perpendicular to L1
(C)	L3 is perpendicular to L4 and L3 is parallel to L2
(D)	L4 is perpendicular to L2 and L4 is parallel to L3

Q.9	Given below are two statements and four conclusions drawn based on the statements. Statement 1: Some soaps are clean. Statement 2: All clean objects are wet. Conclusion I: Some clean objects are soaps. Conclusion II: No clean object is a soap. Conclusion III: Some wet objects are soaps. Conclusion IV: All wet objects are soaps. Which one of the following options can be logically inferred?
(A)	Only conclusion I is correct
(B)	Either conclusion I or conclusion II is correct
(C)	Either conclusion III or conclusion IV is correct
(D)	Only conclusion I and conclusion III are correct

Q.10 An ant walks in a straight line on a plane leaving behind a trace of its movement. The initial position of the ant is at point P facing east.

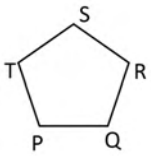
The ant first turns 72° anticlockwise at P, and then does the following two steps in sequence exactly FIVE times before halting.

1. moves forward for 10 cm.
2. turns 144° clockwise.



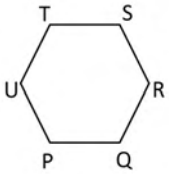
The pattern made by the trace left behind by the ant is

(A)



PQ = QR = RS = ST = TP = 10 cm

(B)



PQ = QR = RS = ST = TU = UP = 10 cm

(C)

SQ = QT = TR = RP = PS = 10 cm

(D)

SW = WR = RP = PT = TQ = QU = US = 10 cm

GATE 2022 Engineering Sciences XE
XE-A: Q.11 – Q.17 Carry ONE mark Each

Q.11	The value of $$\lim_{x\to 0} \frac{1}{x} \int_{2}^{2+x} \left(t + \sqrt{t^2+5}\right) dt$$ is
(A)	0
(B)	4
(C)	5
(D)	6

Q.12	Let $\mathbb{C} = \{z = x + iy : x \text{ and } y \text{ are real numbers, } i = \sqrt{-1}\}$ be the set of complex numbers. Let the function $f(z) = u(x, y) + i\, v(x, y)$ for $z = x + iy \in \mathbb{C}$ be analytic in $\mathbb{C}$, where $u(x, y) = x\, y^3 - y\, x^3$ and $v(x, y) = \frac{x^4}{4} + \frac{y^4}{4} - \frac{3}{2} x^2 y^2$. If $f'(z)$ denotes the derivative of $f(z)$, then
(A)	$\lvert f'(-1 + i)\rvert^2 = 1$
(B)	$\lvert f'(-1 + i)\rvert^2 = 7$
(C)	$\lvert f'(-1 + i)\rvert^2 = 8$
(D)	$\lvert f'(-1 + i)\rvert^2 = 10$

GATE 2022 Engineering Sciences XE

Q.13	If the partial differential equation $$(x+2)\frac{\partial^2 u}{\partial x^2} + 2(x+y)\frac{\partial^2 u}{\partial x\,\partial y} + 2(y-1)\frac{\partial^2 u}{\partial y^2} - 3y^2\,\frac{\partial u}{\partial y} = 0$$ is parabolic on the circle $(x-a)^2 + (y-b)^2 = r^2$, then the values of a, b and r are given by
(A)	$a = 1,\ b = 2,\ r = 1$
(B)	$a = -1,\ b = 2,\ r = 1$
(C)	$a = 1,\ b = -2,\ r = 1$
(D)	$a = -1,\ b = -2,\ r = 1$

Q.14	Let Γ be the positively oriented circle $x^2 + y^2 = 9$ in the xy-plane. If $$\oint_{\Gamma} \left(3y + e^{x\sin x}\right) dx + \left(7x + \sqrt{e^y + 2}\ \right) dy = \alpha\,\pi,$$ where α is a real constant, then α is equal to _____.

Q.15	Let $y_1(x)$ and $y_2(x)$ be two linearly independent solutions of $$x^2\frac{d^2y}{dx^2} - 2x\frac{dy}{dx} + 2y = 0, \qquad x > 0.$$ Let $W(y_1, y_2)(x)$ denote the Wronskian of $y_1(x)$ and $y_2(x)$ at x. If $W(y_1, y_2)(1) = 1$ then $W(y_1, y_2)(2)$ is equal to _____.

Q.16	Let $A = \begin{bmatrix} 2 & 0 & 1 & 1 \\ 1 & 2 & 5 & -5 \\ 0 & 0 & 3 & 0 \\ 0 & 0 & 1 & 3 \end{bmatrix}$. Then the sum of the geometric multiplicities of the distinct eigenvalues of A is equal to _____.

Q.17	In a cosmopolitan city, the population comprises of 30% female and 70% male. Suppose that 5% of female and 30% of male in the population are foreigners. A person is selected at random from this population. Given that the selected person is a foreigner, the probability that the person is a female is _____ (*round off to three decimal places*).

Q.18 – Q.21 Carry TWO marks Each

Q.18	Let $f:(0,\infty)\rightarrow\mathbb{R}$ be the continuous function such that $f(x)=2+\frac{g(x)}{x}$ for all $x>0$, where $g(x)=\int_1^x f(t)\,dt$ for all $x>0$. Then $f(2)$ is equal to
(A)	$2+\log_e 2$
(B)	$2-\log_e 2$
(C)	$2+\log_e 4$
(D)	$2-\log_e 4$

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Q.19	Let A and B be $n \times n$ matrices with real entries. Consider the following statements: P: If A is symmetric then $rank(A) =$ Number of nonzero eigenvalues (counting multiplicity) of A. Q: If $AB = \mathbf{0}$ then $rank(A) + rank(B) \leq n$. Then
(A)	both P and Q are TRUE
(B)	P is TRUE and Q is FALSE
(C)	P is FALSE and Q is TRUE
(D)	both P and Q are FALSE

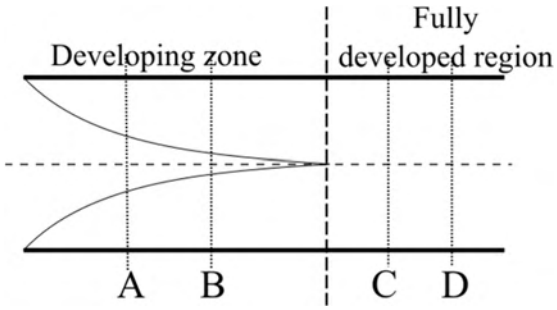
Q.20	Let $f: \mathbb{R}^2 \to \mathbb{R}$ be given by $f(x, y) = 4xy - 2x^2 - y^4 + 1$. The number of critical points where f has local maximum is equal to _____.

Q.21	If the quadrature rule $$\int_{-1}^{1} f(x)dx \approx f(\alpha) + \gamma f(\beta),$$ where α, β and γ are real constants, is exact for all polynomials of degree ≤ 3, then $\gamma + 3(\alpha^2 + \beta^2) + (\alpha^3 + \beta^3)$ is equal to _____.

GATE 2022 Engineering Sciences XE
Fluid Mechanics: XE-B (Q.22 – Q.30 Carry ONE mark Each)

Q.22	A heavy horizontal cylinder of diameter D supports a mass of liquid having density ρ as shown in the figure. Find out the vertical component of force exerted by the liquid per unit length of the cylinder if g is the acceleration due to gravity. 
(A)	$\frac{\pi D^2}{4}\rho g$
(B)	$\frac{\pi D^2}{8}\rho g$
(C)	$\frac{\pi D^2}{2}\rho g$
(D)	$\frac{\pi D^2}{3}\rho g$

GATE 2022 Engineering Sciences XE

Q.23	The figure shows the developing zone and the fully developed region in a pipe flow where the steady flow takes place from left to right. The wall shear stress in the sections A, B, C, and D are given by $\tau_A, \tau_B, \tau_C,$ and τ_D, respectively. Select the correct statement. 
(A)	$\tau_A > \tau_B$
(B)	$\tau_B > \tau_A$
(C)	$\tau_C > \tau_B$
(D)	$\tau_C > \tau_D$

Q.24 The left hand column lists some non-dimensional numbers and the right hand column lists some physical phenomena. Indicate the correct combination

1. Reynolds number	i. Wave drag
2. Froude number	ii. Compressible flow
3. Mach number	iii. Viscous drag
4. Weber number	iv. Spray formation

(A) 1-iii, 2-i, 3-ii, 4-iv

(B) 1-i, 2-ii, 3-iv, 4-iii

(C) 1-iv, 2-iii, 3-iv, 4-iii

(D) 2-iv, 1-iii, 3-ii, 4-i

Q.25	As temperature increases
(A)	the dynamic viscosity of a gas increases.
(B)	the dynamic viscosity of a liquid decreases.
(C)	the dynamic viscosity of a liquid does not change.
(D)	the dynamic viscosity of a gas decreases.

Q.26	Which of the following statement(s) regarding a venturimeter is/are correct?
(A)	In the direction of flow, it consists of a converging section, a throat, and a diverging section.
(B)	In the direction of flow, it consists of a diverging section, a throat, and a converging section.
(C)	It is used for flow measurement at a very low Reynolds number.
(D)	Pressure tappings are provided just upstream of the venturimeter and at the throat.

Q.27	Which of the following statement(s) is/are true for streamlines in a steady incompressible flow?
(A)	Two streamlines cannot intersect each other.
(B)	Flow rate increases between two diverging streamlines.
(C)	Flow rate decreases between two diverging streamlines.
(D)	Stream function has a constant value along a streamline.

Q.28	A flow has a velocity potential given by $\phi = Ax^3$ where 'A' is a non-zero constant. Which of the following statement(s) is/are true about the flow?
(A)	The flow is incompressible.
(B)	The flow is irrotational.
(C)	The flow has local acceleration.
(D)	The flow has convective acceleration.

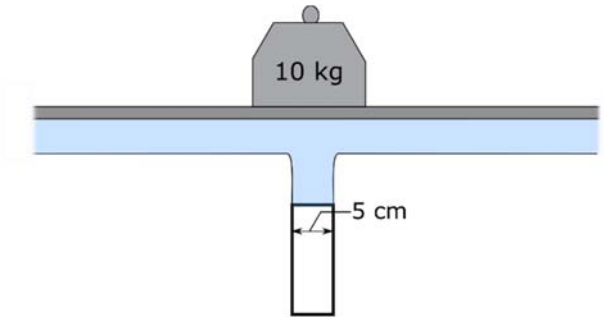
Q.29	A boundary layer develops due to a two-dimensional steady flow over a horizontal flat plate. Consider a vertical line away from the leading edge which extends from the wall to the edge of the boundary layer. Which of the following quantity/quantities is/are not constant along the vertical line? u and v represent the components of velocity in the direction along the plate and normal to it, respectively and x is taken along the length of the plate while p is the pressure. Neglect body forces.
(A)	u
(B)	$\frac{\partial u}{\partial x}$
(C)	v
(D)	p

Q.30

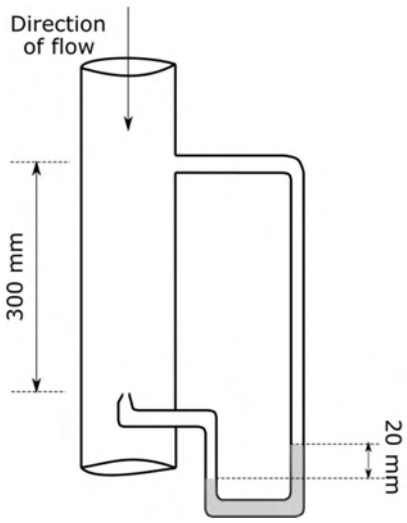
A 10 kg mass placed on an infinitely long horizontal massless flat platform is to be supported by a steady vertical water jet as shown in the figure. The diameter of the jet is 5 cm. What minimum average velocity is required to hold the mass in place?

Assume $\rho_{water} = 1000\ \text{kg/m}^3$, $g = 10\,\frac{\text{m}}{\text{s}^2}$ and $\pi = 3.14$. Neglect friction.

(Round off to two decimal places)



GATE 2022 Engineering Sciences XE
Q.31 – Q.43 Carry TWO marks Each

Q.31	Consider an inviscid flow through a smooth pipe which has a pitot-static tube arrangement as shown. Find the centre-line velocity in the pipe. Consider that the density of the fluid is 1000 kg/m^3, acceleration due to gravity is 10 m/s^2, and the specific gravity of the manometric fluid is 11. 
(A)	2 m/s
(B)	3 m/s
(C)	5 m/s
(D)	7 m/s

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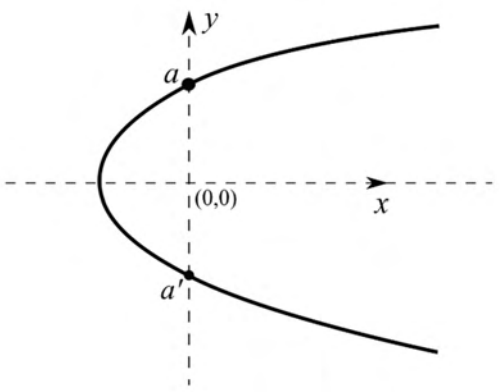
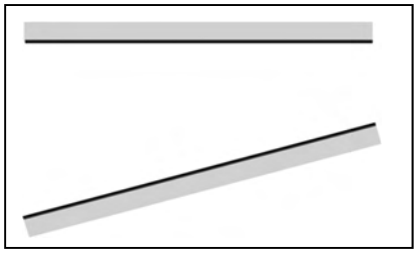
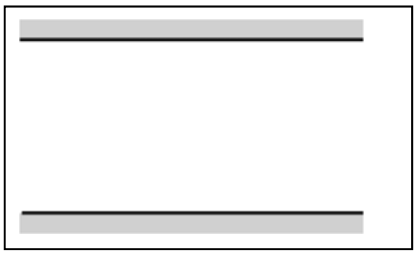
Q.32	The speed of propagation, c, of a capillary wave depends on the density of the fluid, ρ, the wavelength of the wave, λ, and the surface tension, σ. If the density and wavelength remain constant, halving the surface tension would lead to a new velocity, c', given by
(A)	$c' = 2c$
(B)	$c' = \sqrt{2}c$
(C)	$c' = \frac{c}{\sqrt{2}}$
(D)	$c' = c$

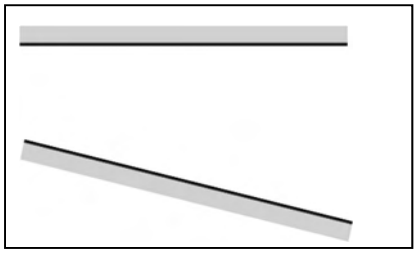
Q.33	A two-dimensional flow field is described by a combination of a source of strength m at the origin and a uniform flow, U, in the positive x-direction such that the velocity potential is given by $\phi = Ux + \frac{m}{2\pi}\ln\sqrt{x^2+y^2}$ The stagnation streamline is shown in the figure. Find the distance aa'. 
(A)	$\frac{m}{U}$
(B)	$\frac{2m}{U}$
(C)	$\frac{8m}{U}$
(D)	$\frac{m}{2U}$

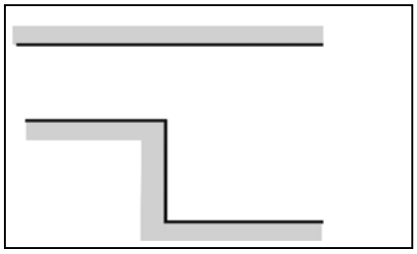
Q.34	A typical boundary layer over a flat plate has a linear velocity profile with zero velocity at the wall and freestream velocity, U_∞, at the outer edge of the boundary layer. What is the ratio of the momentum thickness to the thickness of the boundary layer?
(A)	$1/2$
(B)	$1/4$
(C)	$1/6$
(D)	$1/3$

Q.35 Identify the configuration(s) in which steady two-dimensional internal flow may show boundary layer separation if the flow direction is left to right.

(A) 

(B) 

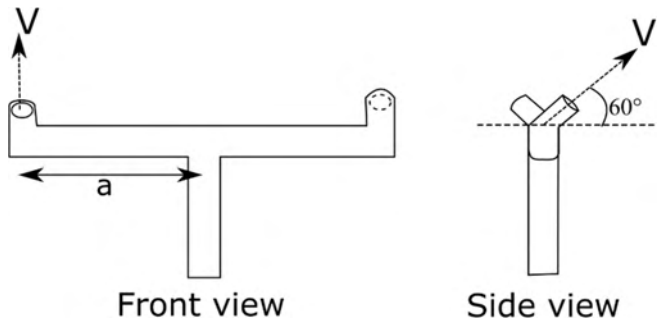
(C) 

(D) 

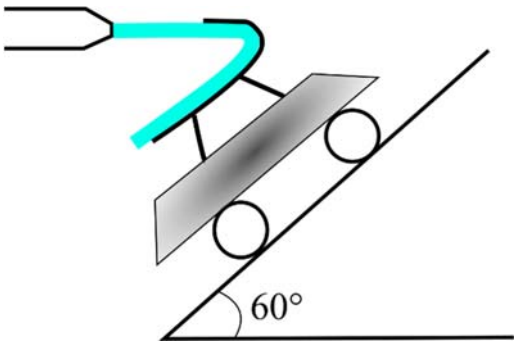
Q.36	Consider steady fully developed flow of a liquid through two large horizontal flat parallel plates separated by a distance of 2 mm. One of the plate is fixed and the other plate moves at a speed of 0.5 m/s. What is the magnitude of the pressure gradient (in Pa/m) in the direction of the flow required to ensure that the net flow through the plates is zero? Dynamic viscosity of the liquid is 5×10^{-4} Ns/m^2 *(Round off to the nearest integer)*

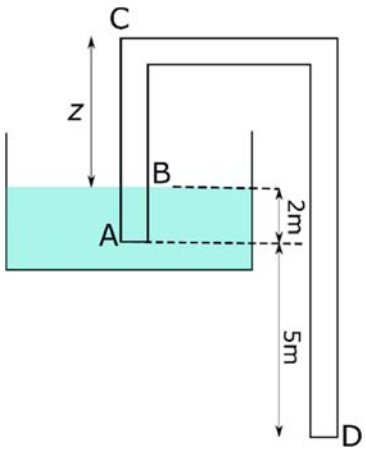
Q.37	Consider two-dimensional turbulent flow of air over a horizontal flat plate of length 1 m. Skin friction coefficient at a length x from the leading edge of the plate is obtained as: $c_f = \frac{0.06}{(\mathrm{Re}_x)^{0.2}}$ where, Re_x is the local Reynolds number. Find out the drag force per unit width (in N/m^2) on the plate if the free stream air velocity is 10 m/s. Density and dynamic viscosity of air are given as 1.2 kg/m^3 and 1.83×10^{-5} N-s/m^2, respectively. (*Round off to three decimal places*)

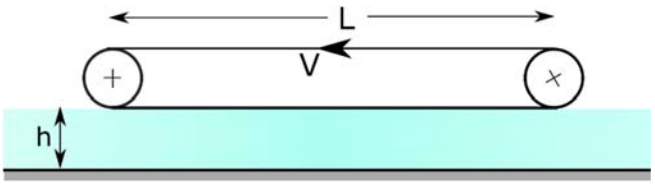
Q.38	For an inviscid fluid with density 1 kg/m^3, the Cartesian velocity field is given as: $\mathbf{u} = (-2x + y)t\mathbf{i} + (2x + y)t\mathbf{j}$ m/s Neglecting the body forces, find the magnitude of pressure gradient in (Pa/m) at (x, y) = (1 m, 1 m) at t = 1 s. *(Round off to two decimal places)*

Q.39	Consider a lawn sprinkler with horizontal arms of radius, a = 10 cm which has water introduced vertically through the centre, as shown in the figure. The exit area of the jet is 25 cm^2 and the jet velocity is 1 m/s. The water is ejected orthogonal to the sprinkler arm and the jet makes an angle of 60° with the horizontal plane. Find the torque (in N-m) required to hold the sprinkler stationary. Consider water density 1000 kg/m^3. Neglect the effects of friction and gravity. *(Round off to two decimal places)* 

Q.40	A wooden cylinder (specific gravity = 0.6) of length L and diameter D floats in water (density 1000 kg/m^3). Find out the minimum value of D/L for which the cylinder floats with its axis vertical. *(Round off to three decimal places)*

Q.41	Consider a cart of mass 10 kg placed on an inclined plane (angle of inclination 60° with horizontal) as shown in the figure. A turning vane of negligible weight is mounted on the cart. A horizontal steady water jet is issued from a stationary nozzle of area 0.1 m^2 and strikes the turning vane as shown in the figure. The vane turns the jet downward parallel to the inclined plane. Find out the minimum jet velocity (in m/s) which will not allow the cart to come down. Neglect friction, consider density of water = 1000 kg/m^3 and acceleration due to gravity = 10 m/s^2. *(Round off to two decimal places)* 

Q.42	A siphon is used to drain out water (density 1000 kg/m^3) from a tank as shown in the figure. What can be the maximum height z (in meter) of the point C? Consider acceleration due to gravity = 10 m/s^2, pressure at point A = 101 kPa, vapour pressure of water = 29.5 kPa and neglect friction. *(Round off to two decimal places)* 

Q.43	The horizontal belt of negligible weight shown in the figure moves with a steady velocity (V) of 2.5 m/s and skims over the top surface of an oil-film of depth h = 3 cm. The length (L) and width (b) of the belt are, respectively, 2 m and 60 cm. Find the viscosity of the oil (in Pa-s), given that the minimum power required to move the belt is 100 W. Neglect the end effects. *(Round off to two decimal places)* 

GATE 2022 Engineering Sciences XE
(Materials Science XE-C) Q.44 – Q.52 Carry ONE mark Each

MCQ

Q.44	Number of atoms per unit area of the (110) plane of a body centered cubic crystal, with lattice parameter 'a', is
(A)	$\frac{1}{a^2}$
(B)	$\frac{\sqrt{2}}{a^2}$
(C)	$\frac{1}{\sqrt{3}a^2}$
(D)	$\frac{1}{\sqrt{2}a^2}$

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Q.45 Match the following materials with their corresponding bonding types.

Material	**Bonding**
P: $Cu_{0.5}Al_{0.5}$	1: Ionic
Q: ZnS	2: Covalent
R: Na_2O	3: Metallic
S: Li_4SiO_4	4: Mixed

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

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

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

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

GATE 2022 Engineering Sciences XE

Q.46	In an ideal rubber, the primary factor responsible for elasticity up to small strains is
(A)	Change in both enthalpy and entropy
(B)	Change in enthalpy, but no change in the entropy
(C)	No change in enthalpy, but change in the entropy
(D)	Neither a change in enthalpy, nor a change in the entropy

GATE 2022 Engineering Sciences XE

Q.47	Which one of the following statements is true for an intrinsic semiconductor?
(A)	Electrical conductivity increases with increasing temperature and pressure
(B)	Electrical conductivity increases with increasing temperature and decreasing pressure
(C)	Electrical conductivity increases with decreasing temperature and increasing pressure
(D)	Electrical conductivity increases with decreasing temperature and pressure

GATE 2022 Engineering Sciences XE

Q.48	A differential scanning calorimetry (DSC) experiment tracks the heat flow into or out of a system as a function of temperature. If the experiments given in the options below are performed at 1 atmospheric pressure, then in which case will the DSC thermogram exhibit a spike, either upward or downward?
(A)	Heating 10 mg of pure Cu from 323 K to 673 K
(B)	Cooling pure water from 323 K to 278 K
(C)	Heating pure ice from 263 K to 284 K
(D)	Cooling a Pb-Sn alloy at the eutectic composition from 323 K to 273 K

GATE 2022 Engineering Sciences XE

Q.49	Which one of the following solvent environments will likely result in swelling of solid polystyrene?
(A)	0.1 M NaOH in H_2O
(B)	HCl (aq.) of pH = 6
(C)	Distilled water
(D)	Benzene

GATE 2022 Engineering Sciences XE

MSQ

Q.50	Vickers microhardness (HV) of a ductile material A is higher than another ductile material B. Which of the following is/are true?
(A)	Young's modulus of A is greater than B
(B)	Yield strength of A is greater than B
(C)	Scratch resistance of A is greater than B
(D)	Ductility of A is greater than B

GATE 2022 Engineering Sciences XE

NAT

Q.51	The enthalpy required to create an oxygen vacancy in CeO_2 is 4 eV. The number of oxygen vacancies present per mole of CeO_2 at 1000 K is _____. (Round off to the nearest integer) Given: N_A: Avogadro's number = 6.02×10^{23} $mole^{-1}$ k_B: Boltzmann's constant = 8.62×10^{-5} eV/K

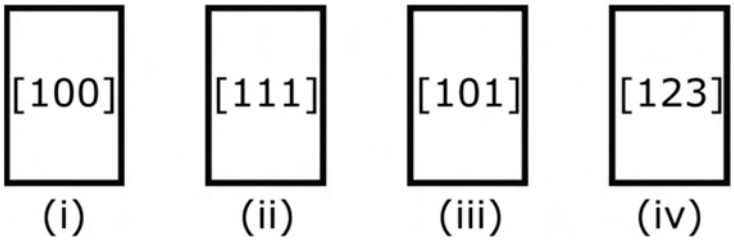
Q.52	An electrochemical reaction is known to occur at +4.50 V against a Li^+/Li reference electrode. The potential of the same reaction against a Zn^{2+}/Zn reference electrode is _____ V. (Round off to two decimal places). Given: E^0 $(Li^+/Li) = -3.04$ V versus Standard Hydrogen Electrode E^0 $(Zn^{2+}/Zn) = -0.77$ V versus Standard Hydrogen Electrode

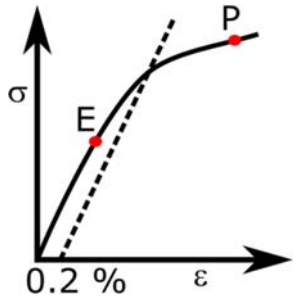
GATE 2022 Engineering Sciences XE
Q.53 – Q.65 Carry TWO marks Each

Q.53	For a binary system at constant pressure, there are two types of invariant reactions: (i) $\alpha \leftrightarrow \beta + \gamma$ (ii) $\alpha + \beta \leftrightarrow \gamma$ Analogously, how many different types of invariant reactions may exist under variable temperature and pressure, for a binary system?
(A)	1
(B)	2
(C)	3
(D)	4

GATE 2022 Engineering Sciences XE

Q.54	For a glass marginally below its glass transition temperature, which one of the following statements is true?
(A)	Glass has higher enthalpy than both the corresponding crystalline and liquid phases
(B)	Glass has lower enthalpy than both the corresponding crystalline and liquid phases
(C)	Glass has higher entropy than the corresponding crystalline phase and lower entropy than the corresponding liquid phase
(D)	Glass has lower entropy than the corresponding crystalline phase and higher entropy than the corresponding liquid phase

Q.55	Which one of the following samples of high-purity aluminium (Al) single crystal will plastically yield at the lowest applied load under ambient conditions? Loading axis is along the direction shown in the schematic. 
(A)	(i)
(B)	(ii)
(C)	(iii)
(D)	(iv)

Q.56	Refer to the schematic shown. Two dog-bone samples, labelled 1 and 2, of a Cu-alloy are tested under tension at room temperature to points “E” and “P”, respectively. Subsequently, they are unloaded completely and metallographically polished. Brinell hardness testing was performed in the gauge section of the samples. Which one of the following can be inferred about the measured Brinell hardness number (BHN)? 
(A)	BHN of 1 > BHN of 2
(B)	BHN of 1 = BHN of 2
(C)	BHN of 1 < BHN of 2
(D)	A conclusion about BHN of samples 1 and 2 cannot be made, with the provided information

GATE 2022 Engineering Sciences XE

Q.57	During the ageing of a homogenized Al-Cu alloy (1 to 4 wt.% Cu) below the GP zone solvus, hardness of the alloy:
(A)	increases monotonically
(B)	decreases monotonically
(C)	first increases and then decreases
(D)	first decreases and then increases

Q.58	A student aims to deposit a thin metallic film on SiO_2 substrate, with an adhesion layer between the metal film and substrate, in a contiguous planar fashion. Island type of growth must be avoided. The student performs an extensive optimization exercise. Which one of the following steps is in the right direction?
(A)	Choose a metallic adhesion layer with very low interfacial energy with the deposited thin film
(B)	Choose a metallic adhesion layer with very low interfacial energy with SiO_2, irrespective of its interaction with metal film to be deposited
(C)	Increase the substrate temperature and decrease the deposition rate
(D)	Use intermittent stages of deposition followed by annealing

GATE 2022 Engineering Sciences XE

MSQ

Q.59	For a diffusional transformation (i.e., growth of β precipitates in an α matrix), which of the following is/are true with increasing degree of undercooling?
(A)	Rate of transformation first increases and then decreases
(B)	Rate of transformation first decreases and then increases
(C)	Thermodynamic driving force increases monotonically
(D)	Mobility of atoms in α matrix remains unchanged

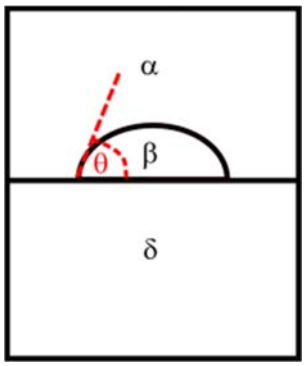
Q.60	A two-phase (α + β) mixture of an A-B binary system has the following properties: (i) Phase α has equal weight percentages of A and B. (ii) Phase β has twice the mole fraction of A compared to B. (iii) The two-phase mixture has equal amounts of α and β. (iv) Atomic mass of A is twice that of B. The mole fraction of A in the resultant two-phase mixture is _____. (Round off to one decimal)

Q.61	It is known that component A diffuses into a solid to a depth of 10 μm in 1 hour at 300 K. Treat diffusion in one dimension. The time taken for A to diffuse to the same depth at 600 K is _____ seconds. (Round off to 1 decimal). Diffusivity of A in the solid is given by $$D_A = D_A^0 \exp\left(-\frac{E_a}{k_B T}\right)$$ D_A^0: Diffusivity coefficient E_a: Activation energy = 0.3 eV k_B: Boltzmann's constant = 8.62×10^{-5} eV/K T: Absolute temperature

Q.62

A spherical β particle nucleates from the α matrix on a non-deformable substrate δ, forming a contact angle of θ as shown in the schematic.

The value of $\frac{\Delta G^*_{het}}{\Delta G^*_{hom}}$ is _____. (Round off to three decimal places)



ΔG^*_{hom}= Gibbs free energy change at the critical radius for homogeneous nucleation

ΔG^*_{het}= Gibbs free energy change at the critical radius for heterogeneous nucleation

α-β interfacial energy = 0.4 J/m^2

α-δ interfacial energy = 0.3 J/m^2

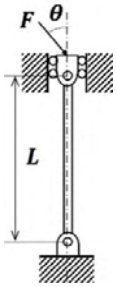
β-δ interfacial energy = 0.02 J/m^2

Q.63	The resistivity of a pure semiconductor at 298 K is 3000 Ωm. Assume that the number of electrons excited (n_e) across the band gap is given by the relation $$n_e = N_A \exp\left(-\frac{E_g}{k_B T}\right)$$ N_A: Avogadro's number = 6.02×10^{23} mole^{-1} k_B: Boltzmann's constant = 8.62×10^{-5} eV/K T: Absolute temperature Mobility of electrons in the semiconductor = 0.14 m^2/(V s) Mobility of holes in the semiconductor = 0.06 m^2/(V s) Absolute charge of an electron = 1.60×10^{-19} C The band gap (E_g) of the semiconductor is _____ eV. (Round off to two decimals)

Q.64	A new glass material is developed to minimize the transmission of the light through the window with glass panel of thickness 5 mm. The refractive index of the glass material is 1.5 and the absorption coefficient can be changed from 0.3 cm^{-1} to 1 cm^{-1}. In the given range of absorption coefficients, the ratio of the maximum to the minimum fraction of the light coming out of the other side of the glass panel is _____. (Round off to two decimal places)

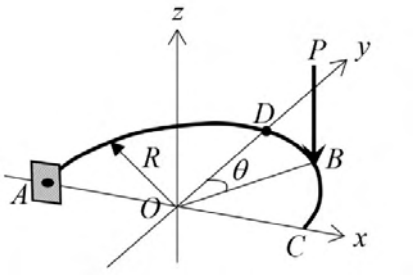
Q.65	The third peak in the X-ray diffraction pattern of a face-centered cubic crystal is at 2θ value of 45°, where 2θ is the angle between the incident and reflected rays. The wavelength of the monochromatic X-ray beam is 1.54 Å. Considering first-order reflection, the lattice parameter of the crystal is _____ Å. (Round off to two decimal places)

GATE 2022 Engineering Sciences XE
Solid Mechanics XE-D (Q.66 – Q.74 Carry ONE mark Each)

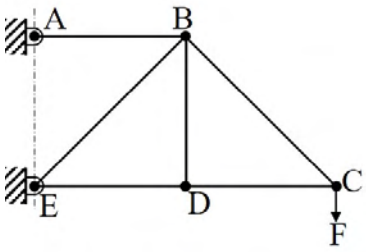
Q.66	A force F is applied at an angle $\theta = 30^o$ on an elastic column as shown in the figure. E and I are respectively the Young's modulus and area moment of inertia. The smallest magnitude of F needed to cause buckling is 
(A)	$\frac{2}{\sqrt{3}}\frac{\pi^2 EI}{L^2}$
(B)	$\frac{\sqrt{3}}{2}\frac{\pi^2 EI}{L^2}$
(C)	$\frac{\pi^2 EI}{2L^2}$
(D)	$\frac{2\pi^2 EI}{L^2}$

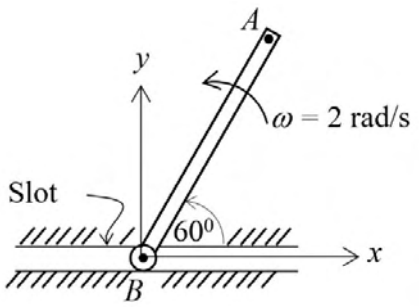
Q.67	The shear stress due to a transverse shear force in a linear elastic isotropic beam of rectangular cross-section
(A)	varies linearly along the depth in the transverse direction of the beam
(B)	is zero at the neutral axis
(C)	is maximum at the neutral axis
(D)	remains constant along the depth in the transverse direction of the beam

GATE 2022 Engineering Sciences XE

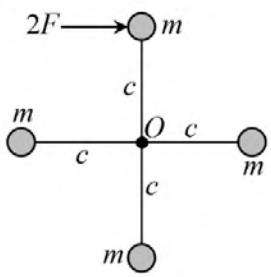
Q.68	A massless semicircular rod held fixed at end A is in the xy-plane, as shown in the figure. A force P along the negative z direction is acting at point B on the rod. The unit vectors along x, y and z directions are denoted respectively as **i**, **j** and **k**. Due to the applied force P, the cross-section of the rod at point D will be subjected to 
(A)	a twisting moment $PR(1-\cos\theta)$ **i**, a bending moment $PR\sin\theta$ **j**, and a shear force $-P$ **k**
(B)	a twisting moment $PR(1-\sin\theta)$ **i**, a bending moment $PR\cos\theta$ **j**, and a shear force P **k**
(C)	a twisting moment $PR(\cos\theta-1)$ **i**, a bending moment $-PR\sin\theta$ **j**, and a shear force $-P$ **k**
(D)	a twisting moment $PR\sin\theta$ **i**, a bending moment $PR\,(1-\cos)\,\theta$ **j**, and a shear force P **k**

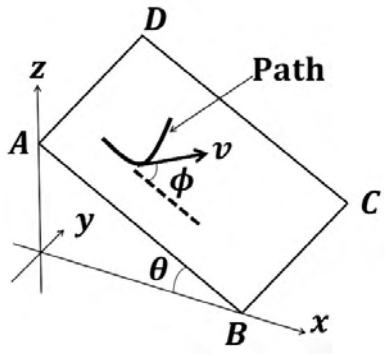
GATE 2022 Engineering Sciences XE

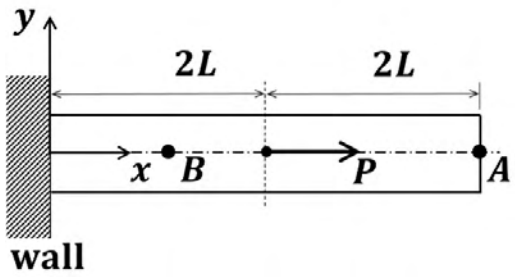
Q.69	In the truss shown in the figure, all the members are pin jointed to each other. The members AB, BD, DE and DC have the same length. For the given loading, which of the following is the correct statement? 
(A)	BD is a zero-force member, and AB and ED are in compression
(B)	AB is in tension, ED is in compression, and BD is a zero-force member
(C)	AB and DC are in tension, and BC is in compression
(D)	ED is in tension, and DC and BC are in compression

Q.70	End B of the 2 m long rigid rod AB is constrained to move horizontally in the slot as shown in the figure and has a velocity of 1.0 **i** m/s. The angular velocity of the rod at the instant shown is 2 rad/s. The unit vectors along x and y directions are denoted respectively as **i** and **j**. The velocity of point A in m/s is then given by 
(A)	$(1-2\sqrt{3})\mathbf{i}+2\mathbf{j}$
(B)	$(1+2\sqrt{3})\mathbf{i}-2\mathbf{j}$
(C)	$-2\sqrt{3}\mathbf{i}+2\mathbf{j}$
(D)	$2\sqrt{3}\mathbf{i}-2\mathbf{j}$

GATE 2022 Engineering Sciences XE

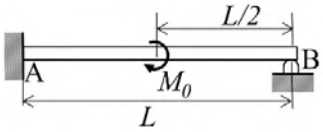
Q.71	The assembly of four masses connected by rigid mass-less rods is kept on a smooth horizontal floor as shown in the figure. Under the applied force $2F$, the magnitude of angular acceleration of the assembly at the instant shown is 
(A)	$\frac{F}{mc}$
(B)	$\frac{F}{2mc}$
(C)	$\frac{2F}{3mc}$
(D)	$\frac{F}{3mc}$

Q.72	A particle is constrained to move at a constant speed on an inclined plane (ABCD) along the curved path shown in the figure. Edges AD and BC are parallel to the y axis. The inclined plane makes an angle θ with the xy-plane. The velocity vector of the particle makes an angle ϕ with the dotted line which is parallel to edge AB. If the speed of the particle is 2 m/s, $\phi = 30^{\circ}$, and $\theta = 40^{\circ}$, then the z-component of the velocity of the particle in m/s is _____ 
(A)	-1.32
(B)	-1.00
(C)	-1.11
(D)	-1.50

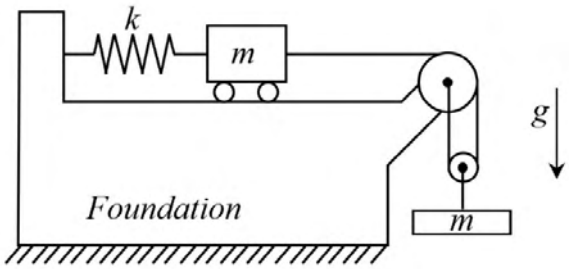
Q.73	A uniform elastic rod of constant cross-section is fixed at its left end as shown in the figure. An axial force P is acting as shown. Assume that plane sections remain plane during deformation. The ratio of axial displacements at point A $(x = 4L)$ to that at point B $(x = L)$ is _____ (rounded off to one decimal place) 

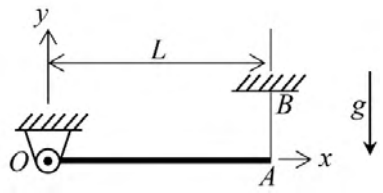
Q.74	A thin-walled spherical pressure vessel has a mean radius of 500 mm and wall thickness of 10 mm. The yield strength of the material is 500 MPa. The internal pressure in MPa at which the spherical pressure vessel will yield according to the Tresca criterion is _____ (rounded off to one decimal place)

GATE 2022 Engineering Sciences XE
Q.75 – Q.87 Carry TWO marks Each

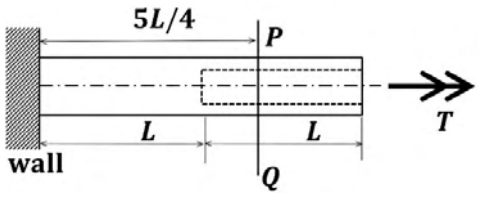
Q.75	The beam in the figure is subjected to a moment M_0 at mid span as shown. Which of the following is the vertical reaction at B? 
(A)	$\frac{9M_0}{8L}$
(B)	$\frac{15M_0}{8L}$
(C)	$\frac{3M_0}{4L}$
(D)	$\frac{9M_0}{4L}$

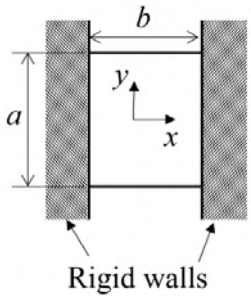
GATE 2022 Engineering Sciences XE

Q.76	A spring-mass system having a mass m and spring constant k, placed horizontally on a foundation, is connected to a vertically hanging mass m with the help of an inextensible string. Ignore the friction in the pulleys and also the inertia of pulleys, string and spring. Gravity is acting vertically downward as shown. The natural frequency of the system in rad/s is 
(A)	$\sqrt{\frac{4k}{3m}}$
(B)	$\sqrt{\frac{k}{2m}}$
(C)	$\sqrt{\frac{k}{3m}}$
(D)	$\sqrt{\frac{4k}{5m}}$

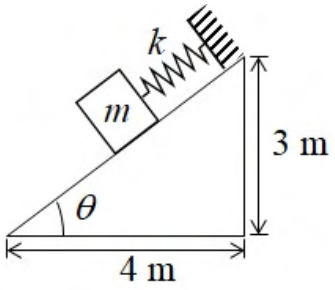
Q.77	One end of a uniform rigid rod OA of length L and mass m is attached to a frictionless hinge at O. The other end of the rod is connected to the roof at B with a mass-less inextensible thread AB. Initially the rod is horizontal and at rest. The gravity is acting vertically downward as shown. Immediately after the thread AB is cut, the reaction on the rod at O is 
(A)	$\frac{mg}{4}$ in the positive y-direction
(B)	$\frac{mg}{2}$ in the negative y-direction
(C)	$\frac{3mg}{4}$ in the negative y-direction
(D)	mg in the positive y-direction

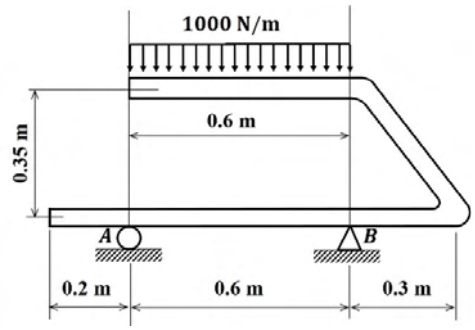
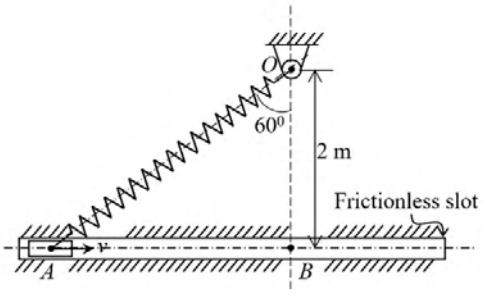
GATE 2022 Engineering Sciences XE

Q.78	A circular shaft is rigidly connected to a wall at one end. The shaft has a solid portion and a hollow portion as shown in the figure. The length of each portion is L and the shear modulus of the material is G. The polar moment of inertia of the hollow portion is J and that of the solid portion is $50J$. A torque T is applied at the right most end as shown. The rotation of the section PQ is 
(A)	$\frac{27TL}{100JG}$
(B)	$\frac{TL}{40JG}$
(C)	$\frac{5TL}{4JG}$
(D)	$\frac{3TL}{4JG}$

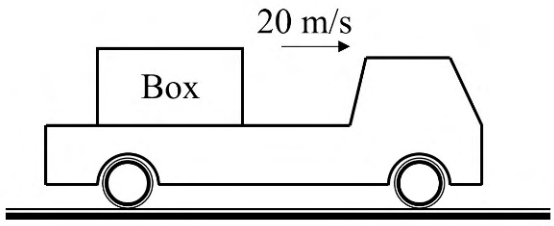
Q.79	**A rectangular plate of uniform thickness having initial length *a* and width *b* is placed between two rigid immovable walls. The temperature of the plate is increased by ΔT. The plate is free to expand along the *y* and *z* directions. The mid-surface of the plate remains in the *xy*-plane. The Poisson's ratio is ν and the coefficient of thermal expansion is α. Assuming that the plate is initially free of stresses, the change in length of the plate after the increase in temperature is given by** 
(A)	$a(1-\nu)\alpha\Delta T$
(B)	$a(1+\nu)\alpha\Delta T$
(C)	$a\alpha\Delta T$
(D)	$2a\alpha\Delta T$

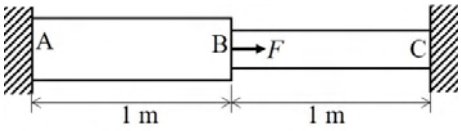
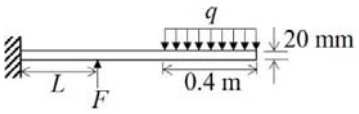
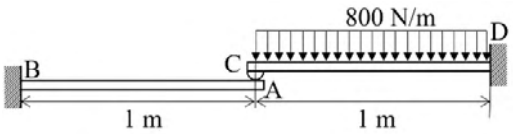
GATE 2022 Engineering Sciences XE

Q.80	**A mass m = 10 kg is attached to a spring as shown in the figure. The coefficient of friction between the mass and the inclined plane is 0.25. Assume that the acceleration due to gravity is 10 m/s^2 and that static and kinematic friction coefficients are the same. Equilibrium of the mass is impossible if the spring force is** 
(A)	**30 N**
(B)	**45 N**
(C)	**60 N**
(D)	**75 N**

Q.81	The frame shown in the figure is subjected to a uniformly distributed load of 1000 N/m over a distance of 0.6 m. Neglecting the weight of the frame, the maximum shear force (in N) in the region between the supports *A* and *B* of the frame is _____. 
Q.82	A slider moving in a frictionless slot is connected with a linear spring *OA* as shown in the figure. The following is known: stiffness of the spring = 2 kN/m, mass of the slider = 10 kg, and the unstretched length of the spring = 1 m. If the slider is released from rest at *A* the magnitude of its velocity (in m/s) when it passes through point *B* is _____(rounded off to the nearest integer) 

Q.83	A sphere A of mass m is thrown into the air at 50 m/s along a direction $\tan^{-1}(3/4)$ up from the horizontal. At the topmost point of its trajectory, it has a central (non-oblique) collision with another sphere B which is at rest on top of a vertical pole. Sphere B has a mass of $3m$. Acceleration due to gravity is 10 m/s^2. Neglect contact friction and air-resistance. If the coefficient of restitution is 0.3, then the speed (in m/s) of sphere A immediately after the collision is_____ (rounded off to one decimal place)

Q.84	The truck shown in the figure is moving on a horizontal road at a speed of 20 m/s. It is carrying a box of mass 1000 kg, which is simply placed on the truck platform. The coefficient of friction between the truck platform and the box is 0.25. Take acceleration due to gravity as 10 m/s^2. Assume uniform deceleration during braking, and the coefficients of static and kinetic friction to be the same. The shortest distance in meters in which the truck can be brought to rest without the box slipping is _____(round off to the nearest integer) 

Q.85	The stepped rod of length 2 m, shown in the figure, is fixed at both ends (A and C). The area of cross-section of portion AB is 200 mm^2 and that of portion BC is 100 mm^2. Force F is applied at section B such that the section is displaced by 0.1 mm in the direction of the force. Young's modulus of the rod is 200 GPa. The applied force F in N is _____ (round off to the nearest integer) 
Q.86	A cantilever beam has a span of 1 m and carries a uniformly distributed load of q = 1250 N/m over a portion as shown. A force F =1000 N acts at a distance L from the fixed end. The distance L is such that the bending moment at the fixed end is zero. The beam has a rectangular cross-section of depth 20 mm and width 24 mm. For this loading, the magnitude of the maximum bending stress in the beam in MPa is_____(round off to the nearest integer) 
Q.87	The figure shows two identical mass-less beams AB and CD, each clamped at one of their ends. The left end of beam CD rests on the right end of beam AB such that the ends of the beams are just in contact. The beams are unstressed before the application of load. Assume no friction at the contact. Now, if a uniformly distributed load of 800 N/m is applied on beam CD, the bending moment at the end B of beam AB in N.m is _____ (rounded off to the nearest integer) 

GATE 2022 Engineering Sciences XE

Thermodynamics XE (E) Q.88 – Q.96 Carry ONE mark each

Q.88	The energy equation for a reversible non-flow process can be expressed as $\delta q = \mathrm{d}u + p\mathrm{d}v$, where q is the heat transfer per unit mass, u is the internal energy per unit mass, p is the pressure, and v is the mass specific volume. This energy equation is not in exact differential form. It can be made exact differential by multiplying with the following integrating factor: (T is the absolute temperature)
(A)	$\frac{1}{p}$
(B)	$\frac{1}{v}$
(C)	$\frac{1}{T}$
(D)	$\frac{1}{uT}$

Q.89	An air standard Diesel cycle consists of four processes: 1-2 (isentropic compression), 2-3 (constant pressure heat addition), 3-4 (isentropic expansion) and 4-1 (constant volume heat rejection). T_4 is the temperature (in K) attained at the end of isentropic expansion (3-4) before constant volume heat rejection. The constant volume heat rejection process (4-1) is replaced by a constant pressure heat rejection process (4a-1) such that T_{4a} is the temperature (in K) reached at the end of isentropic expansion (3-4a), and the state point 1 remains the same. Then
(A)	$T_{4a} < T_4$
(B)	$T_{4a} > T_4$
(C)	$T_{4a} = T_4$
(D)	$T_{4a} = 2T_4$

GATE 2022 Engineering Sciences XE

Q.90	Gas in a cylinder-piston device expands from state 1 (p_1, V_1, T_1) to state 2 (p_2, V_2, T_2). The expansion process is polytropic, i.e., $pV^n = \text{constant}, n \neq 1$. Assuming the ideal gas behaviour, the expression for the work done, W by the system is given by
(A)	$W = p_1 V_1 \ln\left(\frac{T_2}{T_1}\right)$
(B)	$W = \frac{p_2 V_2 - p_1 V_1}{1 - n}$
(C)	$W = p_1 V_1 \ln\left(\frac{V_1}{V_2}\right)$
(D)	$W = p_2 V_2 \ln\left(\frac{p_2}{p_1}\right)$

GATE 2022 Engineering Sciences XE

Q.91	The temperature of the working fluid in a real heat engine cycle changes during heat addition and heat rejection processes. The maximum and minimum temperatures of the cycle are $T_{\max}$ and $T_{\min}$, respectively. If η_C is the thermal efficiency of a Carnot engine operating between these temperature limits, then the thermal efficiency, η of the real heat engine satisfies the relation
(A)	$\eta > \eta_C$
(B)	$\eta < \eta_C$
(C)	$\eta = \eta_C$
(D)	$\eta = 1 + \eta_C$
Q.92	A 1.2 m^3 rigid vessel contains 8 kg of saturated liquid-vapor mixture at 150 kPa. The specific enthalpy of this mixture is _____ kJ/kg (*round off to 2 decimal places*). At 150 kPa: $v_f = 0.001053$ m^3/kg, $v_g = 1.1594$ m^3/kg $h_f = 467.13$ kJ/kg, $h_g = 2693.1$ kJ/kg
Q.93	Air in a closed system undergoes a thermodynamic process from an initial temperature of 300 K to the final temperature of 400 K. The specific heat of air at constant volume, c_v varies linearly with the temperature, T (in K) as $c_v = (0.7 + 0.27 \times 10^{-3} T)$ kJ/(kg K). Change in the specific internal energy of the air in the system is _____ kJ/kg (*round off to 2 decimal places*).

Q.94	A vertical cylinder-piston device contains a fixed mass of gas in equilibrium. The cross-sectional area of the piston is 0.05 m^2. For 150 kPa pressure of the gas in the cylinder, the mass of the piston is _____ kg (*round off to 2 decimal places*). Assume that the atmospheric pressure is 100 kPa and the acceleration due to gravity is 9.81 m/s^2.
Q.95	A steam power plant operates on Rankine cycle. At certain operating condition of the plant, there is a reduction of 20% net work output (kJ/kg) as compared to 100% capacity. This reduction will cause the specific steam consumption (kg/kJ) to increase by _____% (*in integer*).
Q.96	A Carnot heat pump extracts heat from the environment at 250 K, and supplies 6 kW of heat to a room which is maintained at a constant temperature T_H. The heat pump requires a power input of 1 kW for its operation. Then, the temperature of the room T_H is _____ K (*round off to nearest integer*).

GATE 2022 Engineering Sciences XE
Q.97 – Q.109 Carry TWO marks each

Q.97	One of the Maxwell equations is expressed as $\left(\frac{\partial s}{\partial v}\right)_T = \left(\frac{\partial p}{\partial T}\right)_v$, where s is the entropy per unit mass, v is the mass specific volume, p is the pressure, and T is the temperature. In this expression, s is a continuous function of T and v. The derivatives of s are also continuous. Let c_v be specific heat capacity at constant volume for a gas. Then, $\left(\frac{\partial c_v}{\partial v}\right)_T$ can be written as
(A)	$\frac{p}{T}\left(\frac{\partial^2 p}{\partial T^2}\right)_v$
(B)	$\frac{v}{T}\left(\frac{\partial^2 p}{\partial v^2}\right)_T$
(C)	$T\left(\frac{\partial^2 p}{\partial T^2}\right)_v$
(D)	$\frac{1}{T}\left(\frac{\partial^2 p}{\partial v^2}\right)_T$

GATE 2022 Engineering Sciences XE

Q.98	The general relation among the properties x, y and z at any state point can be expressed as $\left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial z}\right)_x \left(\frac{\partial z}{\partial x}\right)_y = -1$. If p, T and h are continuous functions and $c_p = \left(\frac{\partial h}{\partial T}\right)_p$, μ is the Joule-Thomson coefficient, then $\left(\frac{\partial h}{\partial p}\right)_T$ is
(A)	$-\mu c_p$
(B)	$c_p T$
(C)	$-\frac{c_p}{T}$
(D)	μc_p

GATE 2022 Engineering Sciences XE

Q.99	An air-conditioning system consists of an insulated rigid mixing chamber designed to supply air at 24 °C to a building. The mixing chamber mixes two air streams: (i) a cold air stream at 10 °C and mass flow rate $\dot{m}_c$ (kg/s), and (ii) a stream of fresh ambient air at 30 °C and mass flow rate $\dot{m}_a$ (kg/s). Assume air to be an ideal gas with constant specific heat ($c_p = 1.005$ kJ/(kg K), $\gamma = c_p / c_v = 1.4$). Neglect change in kinetic and potential energies as compared to change in enthalpy. Under the steady state condition, the ratio of the mass flow rates of the two streams ($\dot{m}_c / \dot{m}_a$) is
(A)	$\frac{7}{3}$
(B)	$\frac{3}{7}$
(C)	$\frac{2}{7}$
(D)	$\frac{4}{7}$

GATE 2022 Engineering Sciences XE

Q.100	An ideal gas mixture consists of 80% N_2 and 20% O_2 on mass basis. If the total pressure is 300 kPa, then the partial pressure of N_2 (in kPa) is (Molecular weights of N_2 = 28 kg/kmol and O_2 = 32 kg/kmol)
(A)	246.15
(B)	230.34
(C)	254.78
(D)	213.54
Q.101	On the basis of the ideal gas equation and van der Waals equation, the temperatures of a gas at pressure 10 MPa and specific volume 0.005 m^3/kg would be, respectively (Assume gas constant R = 0.3 kJ/(kg K), a = 0.18 m^6 kPa/kg^2 and b = 0.0014 m^3/kg)
(A)	166.67 K and 235.89 K
(B)	166.67 K and 206.40 K
(C)	166.67 K and 267.21 K
(D)	166.67 K and 240.90 K

GATE 2022 Engineering Sciences XE

Q.102	An ideal Brayton cycle operates between maximum and minimum temperatures of T_3 and T_1, respectively. For constant values of T_3 and T_1, the pressure ratio (r_p) for maximum work output is (γ is the specific heat ratio of air)
(A)	$\left(\frac{T_3}{T_1}\right)^{\frac{\gamma}{(\gamma-1)}}$
(B)	$\left(\frac{T_3}{T_1}\right)^{\frac{2\gamma}{(\gamma-1)}}$
(C)	$\left(\frac{T_3}{T_1}\right)^{\frac{\gamma}{2(\gamma-1)}}$
(D)	$\left(\frac{T_3}{T_1}\right)^{\frac{2}{(\gamma-1)}}$
Q.103	An insulated rigid tank of volume 10 m^3 contains air initially at 1 MPa and 600 K. A valve connected to the tank is opened, and air is allowed to escape until the temperature inside the tank drops to 400 K. The temperature of the discharged air can be approximated as the average of the initial and final temperatures of the air in the tank. Neglect kinetic and potential energies of the discharged air. Assume that air behaves as an ideal gas with constant specific heat so that internal energy $u = c_v T$ and enthalpy $h = c_p T$. Then, the final pressure of the air in the tank is _____ MPa (*round off to 2 decimal places*). Assume $c_p = 1.005$ kJ/(kg K), $\gamma = c_p / c_v = 1.4$

Q.104	Steam enters a steam turbine at 5 MPa and 600 °C, and exits as saturated vapor at 50 kPa. Under steady state condition, the turbine loses heat to the surroundings at the rate of 50 kJ per kilogram of steam flowing through the turbine. The ambient temperature is 300 K, and the heat transfer to the surroundings takes place at the outer surface of the turbine at a temperature of 450 K. The irreversibility per unit mass of steam flowing through the turbine is _____ kJ/kg (*round off to 2 decimal places*). Neglect the change in kinetic and potential energies of the steam, and use the following property values: <u>Superheated steam at 5 MPa, 600 °C</u> $v = 0.07870$ m^3/kg, $u = 3273.3$ kJ/kg, $h = 3666.9$ kJ/kg, $s = 7.2605$ kJ/(kg K) <u>Saturated vapour at 50 kPa</u> $v_g = 3.2403$ m^3/kg, $u_g = 2483.2$ kJ/kg, $h_g = 2645.2$ kJ/kg, $s_g = 7.5931$ kJ/(kg K)
Q.105	A heat engine receives heat at 1000 K and rejects heat to the environment at 300 K. The efficiency of the heat engine is half of the efficiency of a Carnot engine operating between the above mentioned temperature limits. The work output from the heat engine is completely used to drive a refrigerator that steadily removes heat from a cold space at 260 K at a rate of 5.2 kW, and rejects the heat to the same environment at 300 K. The COP (coefficient of performance) of the refrigerator is half of the COP of the Carnot refrigerator operating between the same temperature limits as that of the refrigerator. Then, rate of heat supplied to the heat engine is _____ kW (*round off to 2 decimal places*).
Q.106	A room contains air at 25 °C, 100 kPa and 80% relative humidity. If the saturation pressure of water vapor at 25 °C is 3.1698 kPa, then the specific humidity of air is _____ kg of water vapor / kg of dry air (*round off to 4 decimal places*).

Q.107	An insulated rigid container is divided into two parts by a thin partition. One part of the container contains 6 kg of saturated liquid-vapor mixture with a dryness fraction of 0.7 at 0.3 MPa. The other part contains 12 kg of saturated liquid at 0.6 MPa of the same substance. When the partition is removed and the system attains equilibrium, the final specific volume of the mixture is _____ m^3/kg (*round off to 2 decimal places*). Use the following property values: At 0.3 MPa : $v_f = 0.001073\ m^3/kg$, $v_g = 0.60582\ m^3/kg$ At 0.6 MPa : $v_f = 0.001101\ m^3/kg$, $v_g = 0.31560\ m^3/kg$
Q.108	During a steady state air-conditioning process, air enters a heating section at 15 °C with 40% relative humidity and leaves at 30 °C. Assuming the heating process takes place at 100 kPa, the relative humidity of the air at exit is _____ % (*round off to nearest integer*). Saturation pressures of water vapor at 15 °C and 30 °C are 1.7057 kPa and 4.2469 kPa respectively.
Q.109	Steam enters a steam turbine at 10 MPa and 600 °C with a mass flow rate of 16 kg/s. The steam exits the turbine as saturated vapor at 10 kPa. Under steady state condition, the turbine generates 16.2 MW power. If the ambient temperature is 25 °C, the rate of entropy generation in the turbine is _____ kW/K (*round off to 2 decimal places*). Neglect the change in kinetic and potential energies of the steam, and use the following property values: <u>Superheated steam at 10 MPa, 600 °C</u> $v = 0.03837\ m^3/kg$, $u = 3241.68$ kJ/kg, $h = 3625.34$ kJ/kg, $s = 6.9028$ kJ/(kg K) <u>Saturated vapour at 10 kPa</u> $v_g = 14.67355\ m^3/kg$, $u_g = 2437.89$ kJ/kg, $h_g = 2584.63$ kJ/kg, $s_g = 8.1501$ kJ/(kg K)

GATE 2022 Engineering Sciences XE
Polymer Science and Engineering XE-F (Q.110 – Q.118 Carry ONE mark Each)

Q.110	Interfacial polymerization can be used to prepare
(A)	Nylon 6
(B)	Nylon 66
(C)	Polyacrylonitrile
(D)	Poly(butyl acrylate)
Q.111	In a rubber sample with a Mooney viscosity of 60 ML(1+4) 100 °C, the number 4 signifies
(A)	Applied shear rate in s^{-1}
(B)	Number of samples tested
(C)	Time in minutes after starting the motor when the measurement is taken
(D)	Preheating time in minutes
Q.112	The initiator system which can be used for free radical polymerization at 5 °C is
(A)	$FeSO_4$ + *t*-butyl hydroperoxide
(B)	Azobisisobutyronitrile
(C)	Potassium persulfate
(D)	Benzoyl peroxide

Q.113	Weather resistance of high impact polystyrene can be improved by blending polystyrene with
(A)	Styrene butadiene rubber
(B)	Natural rubber
(C)	Ethylene propylene rubber
(D)	Nitrile rubber
Q.114	Which of the following is a discontinuous polymer processing operation?
(A)	Calendering
(B)	Extrusion
(C)	Film blowing
(D)	Thermoforming
Q.115	The blend of polyethylene and polypropylene is
(A)	Immiscible due to enthalpic constraints
(B)	Immiscible due to entropic constraints
(C)	Miscible as they are polyolefins
(D)	Miscible due to comparable solubility parameters

GATE 2022 Engineering Sciences XE

Q.116	Toughness in a polymer can be inferred from
(A)	Izod impact strength
(B)	Depth of indentation
(C)	Area under the stress-strain curve
(D)	Charpy impact strength
Q.117	Which of the following polymers are polyesters?
(A)	Poly(acrylic acid)
(B)	Poly(lactic acid)
(C)	Polyhydroxybutyrate
(D)	Poly(ε-caprolactone)
Q.118	The functionality of adipic acid for condensation reaction with glycerol is _____ (*in integer*).

GATE 2022 Engineering Sciences XE
Q.119 – Q.131 Carry TWO marks Each

Q.119	From the dynamic mechanical analysis of a polymer sample with a phase angle of 30°, the relationship between storage modulus (E') and loss modulus (E") can be expressed as
(A)	$E' = \sqrt{3}\, E''$
(B)	$2E' = \sqrt{3}\, E''$
(C)	$E'' = \sqrt{3}\, E'$
(D)	$2E'' = \sqrt{3}\, E'$
Q.120	Match the properties in **Column A** with their respective unit in **Column B**

Column A	**Column B**
P. Surface resistivity	1. Ohm-cm
Q. Volume resistivity	2. S cm^{-1}
R. Coefficient of thermal expansion	3. Ohm
S. Electrical conductivity	4. K^{-1}

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

GATE 2022 Engineering Sciences XE

<table>
<tr><td>Q.121</td><td colspan="2">Match the following polymer product with its most appropriate processing technique</td></tr>
<tr><td></td><td>Polymer product</td><td>Processing technique</td></tr>
<tr><td></td><td>P. Bottle</td><td>1. Extrusion</td></tr>
<tr><td></td><td>Q. Blister packaging</td><td>2. Pultrusion</td></tr>
<tr><td></td><td>R. Reinforced electric poles</td><td>3. Injection blow molding</td></tr>
<tr><td></td><td>S. Sewage pipes</td><td>4. Thermoforming</td></tr>
<tr><td>(A)</td><td colspan="2">P-3; Q-4; R-1; S-2</td></tr>
<tr><td>(B)</td><td colspan="2">P-3; Q-4; R-2; S-1</td></tr>
<tr><td>(C)</td><td colspan="2">P-4; Q-3; R-2; S-1</td></tr>
<tr><td>(D)</td><td colspan="2">P-3; Q-2; R-4; S-1</td></tr>
</table>

GATE 2022 Engineering Sciences XE

Q.122	Match the following additives to their respective functions

	Additive	**Function**
	P. *p*-phenylenediamine	1. Flame retardant
	Q. Trixylyl phosphate	2. Impact modifier
	R. Polybutadiene rubber	3. Nucleating agent
	S. Talc	4. Antiozonant

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

GATE 2022 Engineering Sciences XE

Q.123	Match the polymers with their characteristic infrared (IR) stretching frequency
	Polymer — **IR stretch (cm^{-1})** P. Polyurethane — 1. ~2234 Q. Polyethylene — 2. ~1151 R. Polysulfone — 3. ~1720 S. Acrylonitrile-butadiene-styrene copolymer — 4. ~2914
(A)	P-4; Q-3; R-2; S-1
(B)	P-3; Q-4; R-2; S-1
(C)	P-3; Q-4; R-1; S-2
(D)	P-3; Q-2; R-4; S-1

GATE 2022 Engineering Sciences XE

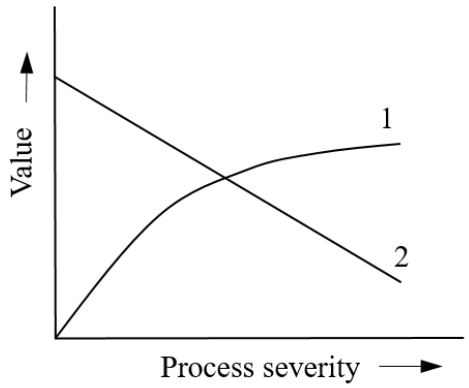
Q.124	Match the following polymers to the most appropriate product
	Polymer — **Product** P. Expanded polystyrene — 1. Motor bearings Q. Polyether ether ketone — 2. TV cabinet R. Polycarbonate — 3. Sound proof walls S. Poly(butylene terephthalate) — 4. Safety glass
(A)	P-2; Q-1; R-4; S-3
(B)	P-2; Q-4; R-1; S-3
(C)	P-3; Q-1; R-2; S-4
(D)	P-3; Q-1; R-4; S-2

GATE 2022 Engineering Sciences XE

Q.125	Match the polymers to the polymerization method used for their synthesis
	Polymer — **Polymerization method** P. Linear low density polyethylene — 1. Ring opening Q. Nylon 6 — 2. Ziegler-Natta R. Styrene-butadiene rubber — 3. Condensation S. Aromatic polyamide — 4. Emulsion
(A)	P-2; Q-1; R-4; S-3
(B)	P-2; Q-1; R-3; S-4
(C)	P-2; Q-3; R-4; S-1
(D)	P-2; Q-4; R-1; S-3
Q.126	If 5 g of a monodisperse polystyrene sample of molecular weight 10,000 g mol^{-1} is mixed with 15 g of another monodisperse polystyrene sample of molecular weight 20,000 g mol^{-1}, then the polydispersity of the resulting mixture is _____ (*rounded off to two decimal places*).
Q.127	For a polymer sample with a viscosity of 6×10^{11} poise, if the apparent plateau modulus of 3×10^{6} dyne cm^{-2} drops to zero above a certain temperature, the relaxation time of the polymer is _____ days (*rounded off to one decimal place*).

Q.128	The thermal conductivity values of glass fiber and epoxy resin are 1.05 W m^{-1} K^{-1} and 0.25 W m^{-1} K^{-1}, respectively. The thermal conductivity of a glass fiber reinforced epoxy composite with a fiber content of 60% by volume along the fiber direction is _____ W m^{-1} K^{-1} (*rounded off to two decimal places*).
Q.129	The tensile modulus of a thermosetting polyester resin and glass fiber are 3 GPa and 80 GPa, respectively. If a tensile stress of 110 MPa is applied along the fiber direction on a continuous uniaxially aligned glass fiber reinforced thermosetting polyester composite with a fiber content of 60% by volume, the resulting strain will be _____$\times 10^{-3}$ (*rounded off to one decimal place*).
Q.130	The amount of low molecular weight plasticizer with a T_g of -60 °C that must be added to nylon 6 to reduce its T_g from 50 °C to 30 °C is _____ % (*rounded off to nearest integer*).
Q.131	The enthalpy of fusion for a polymer is found to decrease from 135.6 J g^{-1} to 120 J g^{-1} after five years of use. If the enthalpy of fusion of the same polymer with 100% crystallinity is 290 J g^{-1}, then the loss in crystallinity after five years is _____ % (*rounded off to one decimal place*).

GATE 2022 Engineering Sciences XE
Food Technology XE-G (Q.132 – Q.140 Carry ONE mark Each)

Q.132	Which among the given options truly depict the lines 1 and 2 in the figure below with respect to the effect of heat processing on food?
	
(A)	1-Safety, 2-Quality
(B)	1-Yield, 2-Safety
(C)	1-Yield, 2-Quality
(D)	1-Quality, 2-Safety
Q.133	Homogenization of milk leads to disintegration of fat globules by
(A)	Turbulence and pasteurization
(B)	Pasteurization and cavitation
(C)	Pasteurization and pressurization
(D)	Turbulence and cavitation

Q.134	The lowest water activity (a_w) supporting the growth of *Staphylococcus aureus* in food under aerobic condition is
(A)	0.98
(B)	0.91
(C)	0.89
(D)	0.86
Q.135	Cultures used in industrial production of yogurt are
(A)	*Lactococcus lactis subsp. lactis*
(B)	*Streptococcus thermophilus*
(C)	*Leuconostoc mesenteroides subsp. cremoris*
(D)	*Lactobacillus delbrueckii subsp. bulgaricus*

GATE 2022 Engineering Sciences XE

Q.136	In a dairy plant, spray drying technology is used to produce whey powder. The rate of spray drying depends on
(A)	Temperature of the incoming air
(B)	Shape of the cyclone separator
(C)	Diameter of the whey droplet
(D)	Heat transfer coefficient of hot air
Q.137	The parboiling of paddy results into
(A)	Increase in the milling losses
(B)	Increase in the nutritional value of rice
(C)	Increase in the head rice recovery
(D)	Increase in the broken rice percentage
Q.138	One hundred kg paddy is dried from 18% wet basis to 13% wet basis moisture content. The amount of water removed (in kg) from the paddy is _____ (*round off to one decimal place*).
Q.139	The radius of a centrifuge bowl is 0.1 m and is rotating at 850 revolutions per minute. The centrifugal force developed in terms of gravity force (g-force) is _____ (*round off to two decimal places*). Given: Acceleration of gravity (g) = 9.81 m s^{-2} and $\pi = 3.14$

Q.140	In a canning industry, the total process time (F_0) was calculated as 3 min. If each can contains 20 spores having decimal reduction time of 1.6 min, the probability of spoilage would be _____ in 100 cans (*round off to the nearest integer*).

Q.141 – Q.153 Carry TWO marks Each

Q.141	Match the edible oil refining stages given in Column I with their respective functions in Column II Column I — Column II P. Degumming — 1. Separation of waxes Q. Neutralization — 2. Removal of pigments R. Bleaching — 3. Removal of phosphatides S. Winterization — 4. Removal of free fatty acids
(A)	P-3, Q-2, R-1, S-4
(B)	P-2, Q-1, R-3, S-4
(C)	P-3, Q-4, R-2, S-1
(D)	P-3, Q-1, R-2, S-4

Q.142 Make the correct pair of food packaging technology given in Column I with operating principle or description in Column II.

Column I	Column II
P. Aseptic packaging	1. Control of the concentration of O_2 and CO_2 inside the package
Q. Active packaging	2. Create a skin tight package wall
R. Modified atmosphere packaging	3. Independent sterilization of food and packaging material and packaging under sterile environment
S. Vacuum packaging	4. Makes non-passive contribution to product development

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

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

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

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

Q.143	Which of the following is not a caramel flavour producing compound?
(A)	3-Hydroxy-2-methylpyran-4-one
(B)	2H-4-Hydroxy-5-methylfuran-3-one
(C)	3-Hydroxy-2-acetylfuran
(D)	p-Amino benzoicacid
Q.144	Match the size reduction equipment in Column I with the method of operation in Column II. Column I — Column II P. Hammer mill — 1. Compression Q. Burr mill — 2. Impact R. Crushing rolls — 3. Cutting S. Rotary knife — 4. Attrition
(A)	P-2, Q-4, R-1, S-3
(B)	P-3, Q-1, R-2, S-4
(C)	P-4, Q-1, R-2, S-3
(D)	P-3, Q-4, R-2, S-1

Q.145	Most commonly used refrigerant in direct immersion freezing of food is
(A)	Monochlorodifluoromethane
(B)	Dichlorodifluoromethane
(C)	Liquid nitrogen
(D)	Freon
Q.146	Which among the following are ω-6 poly unsaturated essential fatty acids?
(A)	18:2 Linoleic acid
(B)	18:3 α-Linolenic acid
(C)	18:3 γ-Linolenic acid
(D)	20:4 Arachidonic acid
Q.147	Which among the following statements are true with respect to protein denaturation?
(A)	There may be an increase in α-helix and β-sheet structure
(B)	It is an irreversible process
(C)	When fully denatured, globular proteins resemble a random coil
(D)	The peptide bonds are broken

Q.148	Identify the correct pair(s) of milling equipment and the grain for which it is used.
(A)	Mist polisher–Rice
(B)	Break roll–Wheat
(C)	Rubber roll–Pigeon pea
(D)	Beall degermer–Maize
Q.149	Which among the following expression(s) is/are correct?
(A)	Reynolds number = $\frac{Density \times Velocity \times Characteristic\ dimension}{Viscosity}$
(B)	Nusselt number = $\frac{Convective\ heat\ transfer\ coefficient \times Characteristic\ dimension}{Thermal\ conductivity\ of\ solid}$
(C)	Schmidt number = $\frac{Kinematic\ viscosity\ of\ fluid}{Diffusivity}$
(D)	Biot number = $\frac{Convective\ heat\ transfer\ coefficient \times Characteristic\ dimension}{Thermal\ conductivity\ of\ fluid}$

Q.150	In sieve analysis of coffee powder, the particle size distribution is given below Number of particles: 5, 8, 50, 90, 148, 10 Mean particle size (μm): 40, 30, 20, 17.5, 12.5, 10 The Sauter mean diameter (in μm) of the coffee powder is _____ (*round off to one decimal place*).
Q.151	In a dairy processing plant, milk enters a 30 m long and 2 cm diameter tube at 60 °C and leaves at 57 °C. The total heat loss over the tube length is 381.15 W. The specific heat capacity, density, and viscosity of milk are 3.85 kJ kg^{-1} K^{-1}, 1020 kg m^{-3}, and 1.20 cP, respectively. The Reynolds number for the flow is _____ (*round off to the nearest integer*). Given: $\pi = 3.14$
Q.152	Apple juice flows through a steel pipe having thermal conductivity of 50 W m^{-1} K^{-1}. The outer surface of pipe is exposed to ambient environment. The inside diameter and thickness of the pipe are 3 cm and 1.5 cm, respectively. The overall heat transfer coefficient based on inside area is 25 W m^{-2} K^{-1}. If the internal convective heat transfer coefficient is 30 W m^{-2} K^{-1}, the external convective heat transfer coefficient (in W m^{-2} K^{-1}) will be _____ (*round off to two decimal places*).

Q.153	The dry bulb temperature and relative humidity of air inside a storage chamber are 37 °C and 50%, respectively. The saturation pressure of water vapour at 37 °C and barometric pressure are 6.28 kPa and 101.32 kPa, respectively. The humidity ratio of air inside the chamber is _____ kg water (kg dry air)$^{-1}$ (*round off to three decimal places*). Given: Molecular weight of water vapour and dry air are 18.02 g mol^{-1} and 28.97 g mol^{-1}, respectively.

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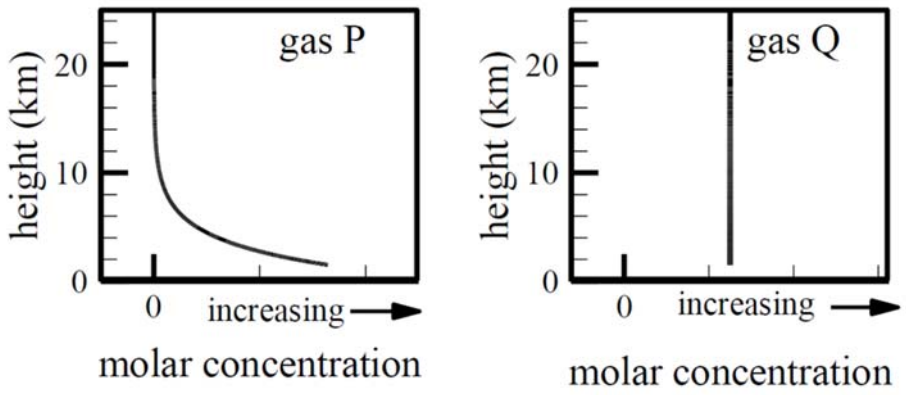
Atmospheric and Oceanic Sciences XE-H (Q.154 – Q.162 Carry ONE mark Each)

Q.154	The figure shows a schematic of vertical profiles of concentrations of two gases P and Q in the atmosphere near a coastal station. The correct pair representing P and Q, respectively, is
	
(A)	water vapor and CO_2
(B)	O_3 and water vapor
(C)	CO_2 and O_3
(D)	N_2 and O_2

Q.155	A form of momentum equation for an incompressible fluid is
	$\rho \frac{D\boldsymbol{V}}{Dt} = -\nabla p + \mu \nabla^2 \boldsymbol{V} + \boldsymbol{B}$ (i) (ii) (iii) (iv) where ρ is density, $\boldsymbol{V}$ is velocity, t is time, p is pressure, μ is viscosity and $\boldsymbol{B}$ represents body force per unit volume. The dimension of term (iii) is (M, L and T stand for mass, length and time, respectively).
(A)	$[L]^1 [T]^{-2}$
(B)	$[M]^1 [L]^{-2} [T]^{-2}$
(C)	$[M]^1 [L]^1 [T]^{-2}$
(D)	$[M]^1 [L]^1 [T]^{-1}$

Q.156	Tropical cyclones usually do not form close to the Equator primarily because
(A)	sea surface temperature at the Equator is too cold.
(B)	beta effect dissipates clouds.
(C)	Coriolis force is too weak.
(D)	vertical shear of the zonal wind is weak.

Q.157	Which one of the following statements regarding equatorial under current (EUC) in the Pacific Ocean is correct?
(A)	EUC flows from west to east.
(B)	EUC flows from east to west.
(C)	EUC flows from north to south.
(D)	EUC flows from south to north.

Q.158	Which one of the following statements is correct regarding the dominant energy balance in the troposphere in a tropical convergence zone?
(A)	Shortwave heating balances longwave radiative cooling.
(B)	Compressional heating balances radiative cooling.
(C)	Radiative cooling balances heating due to viscous dissipation of kinetic energy.
(D)	Condensational heating balances adiabatic cooling.

Q.159	Which one of the following processes is primarily responsible for the poleward transport of energy in the midlatitude troposphere?
(A)	atmospheric tides
(B)	baroclinic waves
(C)	gravity waves
(D)	turbulence in the boundary layer

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Q.160	Which of the following feature(s) characterize the seasonal mean flow in the upper troposphere near 200 hPa level over the Tibetan Plateau during the boreal summer?
(A)	cyclonic
(B)	anticyclonic
(C)	irrotational
(D)	divergent

Q.161	The Rossby number of a synoptic system with a length scale of 1000 km, characteristic velocity scale of 10 m s^{-1} at a latitude where the Coriolis parameter equals 10^{-4} s^{-1}, is _____. (Round off to two decimal places)

Q.162	The ratio of scattering efficiency of red light of wavelength 0.65 µm to blue light of wavelength 0.45 µm by air molecules in the atmosphere is _____. (Round off to two decimal places)

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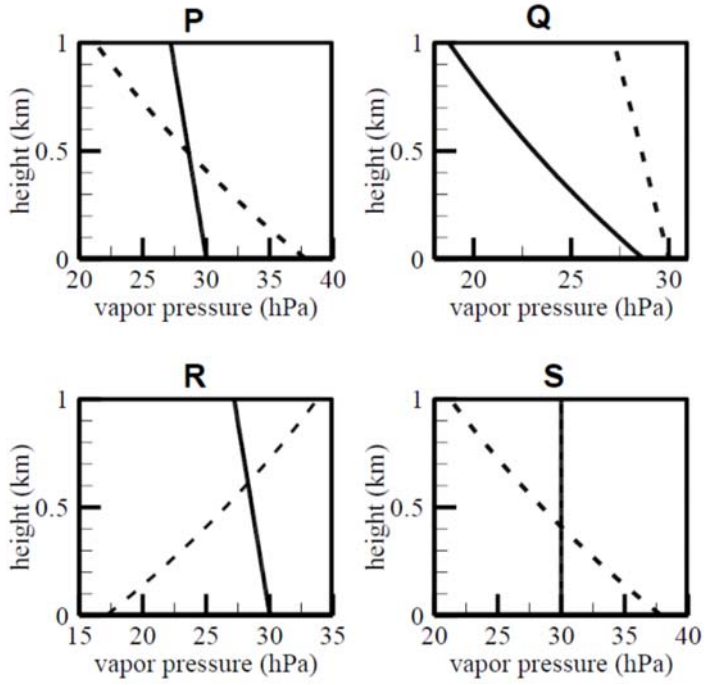
Q.163 – Q.175 Carry TWO marks Each

Q. 163	An unsaturated moist air parcel undergoes adiabatic ascent in atmosphere without mixing with surrounding air. Air is so clean that there is no possibility for heterogeneous nucleation. Which one of the following plots depicts the vertical variation of water vapor pressure (shown as continuous line) and saturation water vapor pressure (shown as dotted/dashed line) of the parcel?
	
(A)	P
(B)	Q
(C)	R
(D)	S

Q.164	A fluid is in solid body rotation in a cylindrical container of radius R rotating with an angular velocity $\boldsymbol{\Omega} = (0, 0, \Omega)$. The circulation per unit area around a circular loop in the horizontal plane of radius r ($r < R$), whose center coincides with the axis of rotation is
(A)	$2\,\Omega$
(B)	Ω^2
(C)	$\Omega/2$
(D)	$\Omega/4$
Q.165	Consider a layer of atmosphere where temperature increases with height. If the concentration of a vertically well-mixed greenhouse gas suddenly increases in this layer, then an immediate consequence is that
(A)	infrared radiation leaving the top of the layer decreases.
(B)	infrared radiation leaving the top of the layer increases.
(C)	infrared radiation leaving the top of the layer remains unchanged.
(D)	the layer becomes optically thinner to infrared radiation.

Q.166	Consider an atmosphere where the mole fractions of N_2, Ar and CO_2 are 7.81×10^{-1}, 9.34×10^{-3} and 4.05×10^{-4}, respectively. This atmosphere exchanges gases with sea water below having temperature and salinity of 20 °C and 35 psu, respectively. In the absence of biological and chemical activity, relative concentrations of dissolved gases in the surface sea water at equilibrium are ordered as
(A)	$[N_2] > [Ar] > [CO_2]$
(B)	$[CO_2] > [N_2] > [Ar]$
(C)	$[N_2] > [CO_2] > [Ar]$
(D)	$[Ar] > [CO_2] > [N_2]$
Q.167	Gravitational forces exerted by the Sun and the Moon are mainly responsible for ocean tides. Which of the following statement(s) regarding ocean tides is/are correct?
(A)	Tidal amplitude corresponding to diurnal period is larger than that of the semi-diurnal period.
(B)	Diurnal time period of lunar forced tides is longer than that of the solar forced tides.
(C)	Tidal amplitudes are larger during a solar eclipse compared to that during a lunar eclipse.
(D)	Tides are absent during equinoxes.

Q.168	Which of the following statement(s) is/are true about northern hemisphere tropical cyclones?
(A)	They have a warm core.
(B)	Their low-level flow is cyclonic.
(C)	Strong wind shear in the vertical is required for their intensification.
(D)	They are characterized by upper-level divergence.
Q.169	In gradient wind balance, which of the following statement(s) is/are true for flow around a region of low pressure in the northern hemisphere?
(A)	The flow is clockwise.
(B)	The flow is anti-clockwise.
(C)	The wind speed is faster than the geostrophic wind.
(D)	The wind speed is slower than the geostrophic wind.

Q. 170	Which of the following statement(s) is/are true regarding biogeochemical cycle in the ocean?
(A)	Shutdown of the biological pump in the ocean would have resulted in higher CO_2 concentration in the atmosphere compared to present-day.
(B)	If atmospheric CO_2 concentration increases, solubility pump would lead to a decrease in dissolved inorganic carbon in the ocean.
(C)	All carbon sequestered by marine photosynthesis settles down on the ocean floor as organic matter.
(D)	Calcification (the process of making shells and skeletons) by marine organisms in the surface ocean layer would lead to an increase in the surface ocean CO_2.

Q.171	Consider the atmosphere to be a heat engine, which converts absorbed radiation to kinetic energy of winds. Let the global mean radiation absorbed be 200 Wm^{-2}. In steady-state, if the global mean kinetic energy dissipation is 10 Wm^{-2}, then the efficiency of the atmospheric heat engine is _____%. (Round off to one decimal place)

Q.172	A drifter on the surface of the ocean performs inertial oscillation. The speed of the drifter is 2 m s^{-1} and the Coriolis parameter at the latitude is 2×10^{-4} s^{-1}. The radius of the inertial oscillation is _____ km. (Round off to the nearest integer)

Q.173	Consider a tornado in cyclostrophic balance. The tangential wind speed at a radial distance of 500 m from the center of the tornado is _____ m s^{-1}, if the pressure gradient at that location in the radial direction is 5 N m^{-3}. Assume the density of air to be 1 kg m^{-3}. (Round off to the nearest integer)

Q.174	Consider two weather stations A and B having the same altitude. Station B is 5 km north of Station A and is always 2 K warmer than Station A. A steady northerly wind blows at 1 m s^{-1}. The change in temperature at Station A in 2 hours is _____ K. (Round off to one decimal place)

Q. 175	Assume the Earth is in radiative equilibrium with effective radiative temperature of 255 K. If the planetary albedo increases by 0.05, then the effective radiative temperature of the planet will be _____ K. (Round off to the nearest integer) Given: Solar constant = 1370 Wm^{-2} Stefan Boltzmann constant = 5.67×10^{-8} Wm^{-2} K^{-4}