XE : ENGINEERING SCIENCES

Duration : Three Hours *Maximum Marks* :100

Read the following instructions carefully.

1. This question paper contains **40** printed pages including pages for rough work. Please check all pages and report discrepancy, if any.
2. Write your registration number, your name and name of the examination centre at the specified locations on the right half of the **O**ptical **R**esponse **S**heet (**ORS**).
3. Using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters corresponding to your paper code.
4. All the questions in this question paper are of objective type.
5. Questions must be answered on **O**ptical **R**esponse **S**heet (**ORS**) by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number on the left hand side of the ORS. **Each question has only one correct answer**. In case you wish to change an answer, erase the old answer completely. More than one answer bubbled against a question will be taken as an incorrect response.
6. This question paper contains seven sections as listed below. Section A is compulsory. Choose **two** more sections from the remaining Sections B through G.

Section	Page No.	Section	Page No.
A. *Engineering Mathematics*	02	E. Thermodynamics	22
B. Fluid Mechanics	04	F. Polymer Science & Engineering	26
C. Materials Science	09	G. Food Technology	30
D. Solid Mechanics	14		

Using HB pencil, mark the sections you have chosen by darkening the appropriate bubbles on the left hand side of the **ORS** provided. **Make sure you have correctly bubbled the sections you have chosen. ORS will not be evaluated if this information is NOT marked.**

7. There are 12 questions carrying 20 marks in XE Section A (Engineering Mathematics) paper, which is compulsory. Questions 1 through 4 are 1-mark questions, and questions 5 through 12 are 2-mark questions.
8. Each of the other XE section papers (Sections B through G) contains 24 questions carrying 40 marks. Questions 1 through 8 are 1-mark questions, questions 9 through 24 are 2-mark questions containing 2 pairs of common data and 1 pair of linked questions. Questions 19 through 22 (2 pairs) are common data questions with 2-marks each, and questions 23 and 24 (1 pair) are linked answer questions with 2-marks each. The answer to the second question of the pair of linked questions will depend on the answer to the first question of the pair. If the first question in the linked pair is wrongly answered or is un-attempted, then the answer to the second question in the pair will not be evaluated.
9. Un-attempted questions will carry zero marks.
10. Wrong answers will carry NEGATIVE marks. In XE Section A, for Q.1 to Q.4, ⅓ mark will be deducted for each wrong answer and for Q.5 to Q.12, ⅔ mark will be deducted for each wrong answer. In all other XE section papers (Sections B through G), for Q.1 to Q.8, ⅓ mark will be deducted for each wrong answer and for Q.9 to Q.22, ⅔ mark will be deducted for each wrong answer. The question pair (Q.23, Q.24) is questions with linked answers. There will be negative marks only for wrong answer to the first question of the linked answer question pair, i.e. for Q.23, ⅔ mark will be deducted for wrong answer. There is no negative marking for Q.24.
11. Calculator (without data connectivity) is allowed in the examination hall.
12. Charts, graph sheets or tables are NOT allowed in the examination hall.
13. Rough work can be done on the question paper itself. Additionally, blank pages are given at the end of the question paper for rough work.

A : ENGINEERING MATHEMATICS (*Compulsory*)

Q. 1 – Q. 4 carry one mark each.

Q.1 Let A and B be two similar square matrices of order two. If 1 and −2 are the eigenvalues of A, then the **Trace** of B is

(A) −2 (B) −1 (C) 1 (D) 2

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

(A) 1 iteration (B) 2 iterations
(C) 3 iterations (D) an undeterminable number of iterations

Q.3 The solution $u(x,t)$ of the one-dimensional heat equation,

$$\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}, x \in \mathbb{R}$$

with a Gaussian initial condition,

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

Q.4 Let C be the boundary of the square given by $0 \le x \le 1,\ 0 \le y \le 1$.

Then $\oint_C (xdy - ydx)$ equals

(A) −2 (B) 0 (C) 1 (D) 2

Q. 5 – Q.12 carry two marks each.

Q.5 Let the eigenvalues of a square matrix A of order two be 1 and 2. The corresponding eigenvectors are $\begin{pmatrix} 0.6 \\ 0.8 \end{pmatrix}$ and $\begin{pmatrix} 0.8 \\ -0.6 \end{pmatrix}$, respectively. Then, the element $A(2,2)$ is

(A) −0.48 (B) 0.48 (C) 1.36 (D) 1.64

Q.6 Let $y_1(x)$ and $y_2(x)$ be two linearly independent solutions of

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

where $q(x)$ is a continuous function in (1,3). If the Wronskian of $y_1(x)$ and $y_2(x)$, at $x = 1$, denoted by $w(y_1, y_2)(1)$, is 1, then $w(y_1, y_2)(2)$ is

(A) $\frac{1}{2^6}$ (B) $\frac{1}{2^3}$ (C) $\frac{1}{2}$ (D) 2

Q.7 Simpson's 1/3 rule applied to

$\int_{-1}^{1}(3x^2+5)dx$, with sub-interval $h=1$, will give

(A) the exact result (B) error between 0.01% to 0.1%
(C) error between 0.1% to 1.0% (D) error > 1.0 %

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

(A) $\left(\frac{5}{6}\right)^n$ (B) $\frac{5}{6}\left(\frac{1}{6}\right)^n$ (C) $\frac{(n-1)!}{n!}\left(\frac{1}{6}\right)^n$ (D) $1-\frac{(n-1)!}{n!}\left(\frac{5}{6}\right)^n$

Q.9 If a complex function $f(z)=u(x,y)+i\,v(x,y)$ is ***analytic***, then

(A) $i\frac{\partial u}{\partial x}+\frac{\partial v}{\partial x}=\frac{\partial u}{\partial y}+i\frac{\partial v}{\partial y}$ (B) $i\frac{\partial u}{\partial x}+\frac{\partial v}{\partial x}=-\frac{\partial u}{\partial y}-i\frac{\partial v}{\partial y}$

(C) $\frac{\partial u}{\partial x}+i\frac{\partial v}{\partial x}=-i\frac{\partial u}{\partial y}+\frac{\partial v}{\partial y}$ (D) $\frac{\partial u}{\partial x}+i\frac{\partial v}{\partial x}=i\frac{\partial u}{\partial y}-\frac{\partial v}{\partial y}$

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

(A) 0 (B) $2\omega^2 y$ (C) $4\omega^2 y$ (D) $-4\omega^2 y$

Q.11 The infinite series

$\sum_{m=1}^{\infty}\frac{(-1)^m x^2}{(1+x^2)^m}$ is

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

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

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

(A) $\mu\leq 333\,m$ (B) $333\,\mu\geq M$ (C) $m\leq\mu\leq M$ (D) $m\leq\mu\leq\frac{M}{333}$

END OF SECTION - A

B : FLUID MECHANICS

Useful Data

Acceleration due to gravity, $g = 10$ m/s^2
Density of water, $\rho_w = 1000$ kg/m^3
Density of air, $\rho_a = 1.2$ kg/m^3
Density of mercury (Hg) $\rho_{Hg} = 13600$ kg/m^3
Dynamic viscosity of water, $\mu_w = 10^{-3}$ kg/(m.s)
Dynamic viscosity of air, $\mu_a = 1.8 \times 10^{-5}$ kg/(m.s)

Q. 1 – Q. 8 carry one mark each.

Q.1 Under what conditions is the equation $\Delta \bullet \rho\vec{V} = 0$ valid ?

P : Steady incompressible flow
Q : Unsteady incompressible flow
R : Steady compressible flow
S : Unsteady compressible flow

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

Q.2 Stream function CANNOT be defined for

(A) two dimensional incompressible flow
(B) two dimensional compressible flow
(C) three dimensional incompressible flow
(D) axisymmetric incompressible flow

Q.3 Which one of the following is an irrotational flow ?

(A) Free vortex flow
(B) Forced vortex flow
(C) Couette flow
(D) Wake flow

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

(A) Froude number
(B) Weber number
(C) Faraday number
(D) Strouhal number

Q.5 Dimples are made on golf balls for which of the following reasons ?

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

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

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

(A) $\dfrac{\partial u}{\partial x} = 0$ (B) $\dfrac{\partial u}{\partial y} = 0$ (C) $\dfrac{\partial^2 u}{\partial x^2} = 0$ (D) $\dfrac{\partial^2 u}{\partial y^2} = 0$

Q.7 Which one among the following boundary layer flows is the LEAST susceptible to flow separation ?

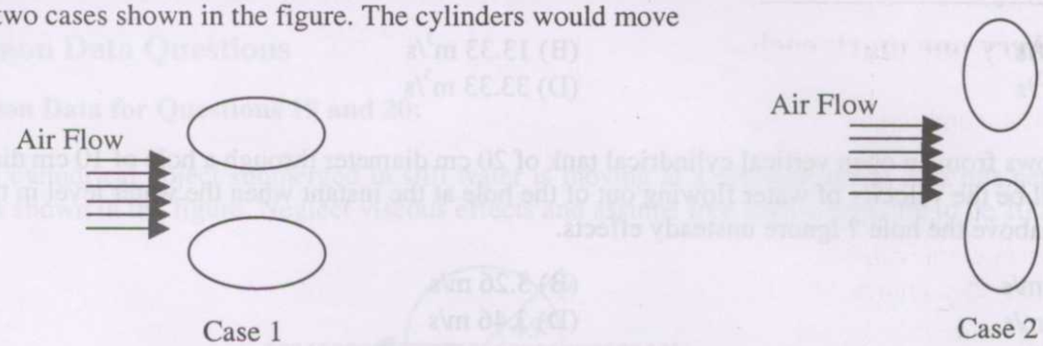
(A) turbulent boundary layer in a favourable pressure gradient

(B) laminar boundary layer in a favourable pressure gradient

(C) turbulent boundary layer in an adverse pressure gradient

(D) laminar boundary layer in an adverse pressure gradient

Q.8 Air from the blower of a hairdryer flows between two identical elliptical cylinders suspended freely, for two cases shown in the figure. The cylinders would move



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

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

(C) away from each other for Case 1 and away from each other for Case 2

(D) towards each other for Case 1 and towards each other for Case 2

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

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

(A) 1280 N (B) 1640 N

(C) 1920 N (D) 2560 N

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

(A) G is located above B (B) B is located above M

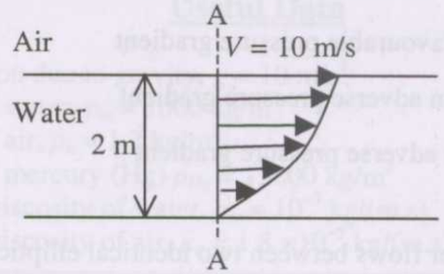
(C) M is located above B (D) M is located above G

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

(A) 1.26 kPa (B) 1.46 kPa

(C) 3.52 kPa (D) 3.92 kPa

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

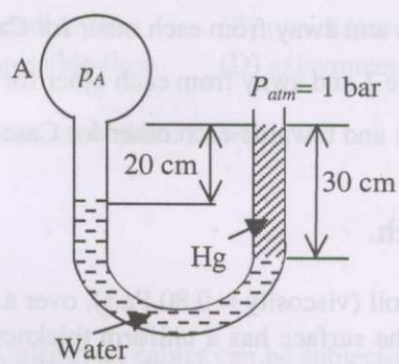


(A) 10 m^3/s (B) 13.33 m^3/s
(C) 20 m^3/s (D) 33.33 m^3/s

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

(A) 3.16 m/s (B) 3.26 m/s
(C) 3.36 m/s (D) 3.46 m/s

Q.14 In the manometer shown in the figure, the pressure p_A of the gas inside bulb A is approximately,



(A) 0.8 bar (B) 1.2 bar (C) 1.4 bar (D) 1.6 bar

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

(A) 4 (B) 8 (C) 16 (D) 32

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

(A) 60 m/s (B) 120 m/s
(C) 180 m/s (D) 240 m/s

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

(A) 21 micron (B) 24 micron
(C) 34 micron (D) 47 micron

Q.18 Determine the correctness or otherwise of the following **Assertion [a]** and the **Reason [r]** :

Assertion [a] : The coefficient of discharge of orifice flow meter is less than that of venturi meter.

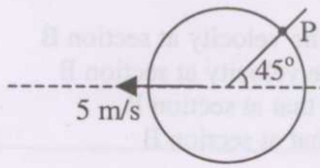
Reason [r] : Orifice flow meter is a differential pressure device.

(A) Both [a] and [r] are true and [r] is the correct reason for [a].
(B) Both [a] and [r] are true but [r] is not the correct reason for [a].
(C) Both [a] and [r] are false.
(D) [a] is true but [r] is false.

Common Data Questions

Common Data for Questions 19 and 20:

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



Q.19 The fluid velocity at point P with respect to the cylinder will be approximately

(A) 3.5 m/s
(B) 5 m/s
(C) 7 m/s
(D) 10 m/s

Q.20 The absolute pressure at point P will be approximately

(A) 137 kPa
(B) 112 kPa
(C) 87 kPa
(D) 62 kPa

Common Data for Questions 21 and 22:

The velocity field for a two dimensional flow is given by: $\vec{V}(x,y,t) = \frac{x}{t}\hat{i} - \frac{y}{t}\hat{j}$

Q.21 The total acceleration is

(A) $\frac{x}{t^2}\hat{i} - \frac{y}{t^2}\hat{j}$
(B) $-\frac{x}{t^2}\hat{i} + \frac{y}{t^2}\hat{j}$
(C) $\frac{2x}{t^2}\hat{i}$
(D) $\frac{2y}{t^2}\hat{j}$

Q.22 The given velocity field is

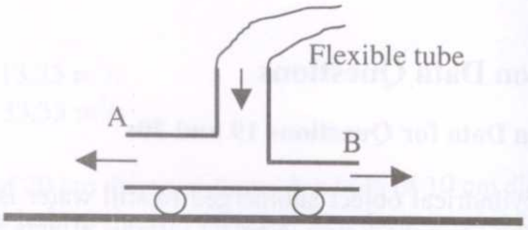
(A) incompressible and rotational
(B) compressible and rotational
(C) incompressible and irrotational
(D) compressible and irrotational

Linked Answer Questions

Statement for Linked Answer Questions 23 and 24:

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

Case 1: The flow rates at sections A and B are equal.
Case 2: The velocities at sections A and B are equal.



Q.23 Which of the following statements are true ?

P : In Case 1, the velocity at section A is twice the velocity at section B
Q : In Case 1, the velocity at section A is half the velocity at section B
R : In Case 2, the flow rate at section A is twice that at section B
S : In Case 2, the flow rate at section A is half that at section B

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

Q.24 Which of the following statements are true ?

P : In Case 1, the system moves to the left
Q : In Case 1, the system moves to the right
R : In Case 2, the system moves to the left
S : In Case 2, the system moves to the right

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

END OF SECTION - B

C : MATERIALS SCIENCE

Useful data

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

1 eV = 1.6×10^{-19}J
1 cal = 4.2 J

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

Hydrogen	0.001
Carbon	0.012
Nitrogen	0.014

Q. 1 – Q. 8 carry one mark each.

Q.1 Equal size spherical balls when packed together will yield maximum theoretical packing of

(A) ~ 52 % (B) ~ 68%
(C) ~ 74 % (D) ~ 86 %

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

(A) Ferrite and cementite (B) Ferrite and austenite
(C) Ferrite and bainite (D) Ferrite and martensite

Q.3 Line broadening in X-ray diffraction pattern occurs on account of

(A) Coarse crystallite size (B) Residual stresses
(C) Multiplicity of phases (D) Coring of crystallites

Q.4 Inter-granular corrosion of austenitic stainless steel is promoted by

(A) Fine grained microstructure (B) Coarse grained microstructure
(C) Soaking steel at 700 °C in air (D) Quenching from 1000 °C

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

(A) High permeability (B) High electrical resistivity
(C) High saturation magentisation (D) Low coercivity

Q.6 During indirect intra-band transition, electrons undergo

(A) change in energy and momentum
(B) change in momentum but no change in energy
(C) change neither in energy nor in momentum
(D) change in energy but no change in momentum

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

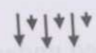
(A) 700 nm
(B) 550 nm
(C) 650 nm
(D) 400 nm

Q.8 Thermal conductivity of a material at a temperature greater than Debye temperature

(A) is independent of temperature
(B) decreases inversely with temperature
(C) increases linearly with temperature
(D) increases exponentially with temperature

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

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

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

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

Q.10 Match the following experimental techniques given in Column I with applications given in Column II.

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

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

Q.11 Match the following materials given in Column I with their applications given in Column II.

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

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

Q.12 Match the following materials given in Column I with their applications given in Column II.

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

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

Q.13 Correlate the material properties given in Column I with the units given in Column II.

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

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

Q.14 If the spacing between two consecutive (110) planes in a BCC material is 0.203 nm, the lattice parameter and radius of the atom of the said material will be

(A) 0.242 nm and 0.110 nm
(B) 0.242 nm and 0.120 nm
(C) 0.287 nm and 0.134 nm
(D) 0.287 nm and 0.124 nm

Q.15 A continuous and aligned carbon fibre reinforced composite is made up of 30 vol% carbon fibre having a modulus of elasticity of 300 GPa dispersed in a polymer matrix which on hardening has a modulus of elasticity of 4 GPa. What will be the modulus of elasticity of the composite in longitudinal and transverse directions of the carbon fibres respectively ?

(A) 92.8 GPa and 5.7 GPa
(B) 211.0 GPa and 9.3 GPa
(C) 304.0 GPa and 7.5 GPa
(D) 92.8 GPa and 6.7 GPa

Q.16 A potential of 10 volts is applied across a parallel plate capacitor which has a plate area of 10^{-4} m^2 and a plate separation of 2×10^{-3}m. If dielectric constant of the material placed between parallel plates is 10, the capacitance and the magnitude of the charge stored between the plates will be

(A) 4.425×10^{-13} F and 4.425×10^{-12} C
(B) 8.850×10^{-13} F and 8.850×10^{-12} C
(C) 4.425×10^{-12} F and 4.425×10^{-11} C
(D) 8.850×10^{-12} F and 8.850×10^{-11} C

Q.17 Conductivity of Silicon at 300 K is 3.16×10^{-4} ohm^{-1} m^{-1} and that of Germanium is 2.12 ohm^{-1} m^{-1} at 300 K. At what temperature would the conductivity of intrinsic Silicon be the same as the conductivity of intrinsic Germanium at 300 K ? (Given: E_g of Silicon at 300 K = 1.12 eV, E_g of Germanium at 300 K = 0.72 eV)

(A) ~ 506 K
(B) ~ 606 K
(C) ~ 726 K
(D) ~ 816 K

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

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

The number average molecular weight and the number average degree of polymerization will be

(A) 15.750 kg/mol and 151
(B) 21.350 kg/mol and 203
(C) 15.750 kg/mol and 302
(D) 21.350 kg/mol and 205

Common Data Questions

Common Data for Questions 19 and 20:

Nickel has FCC structure and its lattice parameter is 0.353 nm. Weight of one mole of Nickel is 0.05871 kg

Q.19 The Ni – Ni nearest neighbour distance (in nm) is

(A) 0.173
(B) 0.223
(C) 0.250
(D) 0.273

Q.20 Theoretical density of Nickel (in kg m^{-3}) is closer to

(A) 8700
(B) 8900
(C) 9100
(D) 9300

Common Data for Questions 21 and 22:

The diffusivity of lithium in Silicon is 10^{-9} m^2 s^{-1} at 1400 K and 10^{-10} m^2 s^{-1} at 1000 K.

Q.21 The value of activation energy (J mol^{-1}) of lithium diffusion in silicon is

(A) 66086
(B) 66986
(C) 67086
(D) 67986

Q.22 The value of jump frequency factor of lithium in silicon in m^2 s^{-1} is

(A) 2.15×10^{-7}
(B) 3.15×10^{-7}
(C) 3.15×10^{-8}
(D) 2.15×10^{-8}

Linked Answer Questions

Statement for Linked Answer Questions 23 and 24:

Aluminum has a density of 2710 kg m^{-3} and weight of one mole of aluminum is 0.02698 kg. The collision time, τ, for electron scattering in Aluminum is 2×10^{-14} s at 300 K.

Q.23 The number of free electrons per m^3 of Aluminum at 300 K is

(A) 6.05×10^{28}
(B) 7.05×10^{28}
(C) 6.05×10^{27}
(D) 7.05×10^{27}

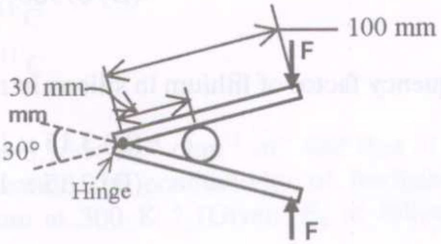
Q.24 The conductivity of aluminum (ohm^{-1} m^{-1}) at 300 K is

(A) 3.40×10^{6}
(B) 4.40×10^{6}
(C) 3.40×10^{7}
(D) 4.40×10^{7}

END OF SECTION - C

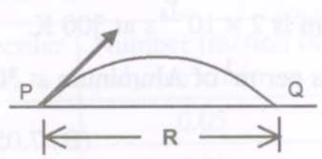
Q. 1 – Q. 8 carry one mark each.

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



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

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

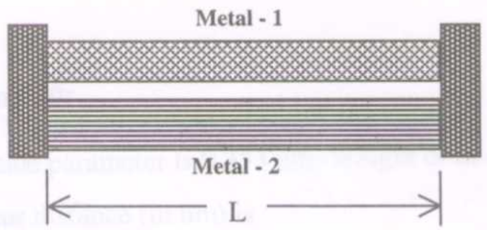


(A) $\sqrt{Rg/2}$ (B) $\sqrt{Rg}$ (C) $\sqrt{2Rg}$ (D) $\sqrt{3Rg}$

Q.3 The state of stress at a point in a loaded body is given as $\sigma_x = +40$ MPa, $\sigma_y = +60$ MPa, $\tau_{xy} = +10$ MPa. The sum of the principal stresses at that point is

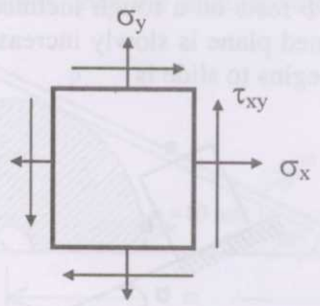
(A) +20 MPa (B) +50 MPa (C) +100 MPa (D) +110 MPa

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



(A) $(E_1 \alpha_1 A_1 + E_2 \alpha_2 A_2)\,\Delta T$
(B) $(1/E_1 \alpha_1 A_1 + 1/E_2 \alpha_2 A_2)^{-1}\,\Delta T$
(C) $(E_1 + E_2)(\alpha_1 + \alpha_2)(A_1 + A_2)\,\Delta T$
(D) $(E_1 \alpha_1 A_1 / E_2 \alpha_2 A_2)\,\Delta T$

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



the shear stress τ_{xy} is

(A) 50 MPa
(B) 70 MPa
(C) 100 MPa
(D) 200 MPa

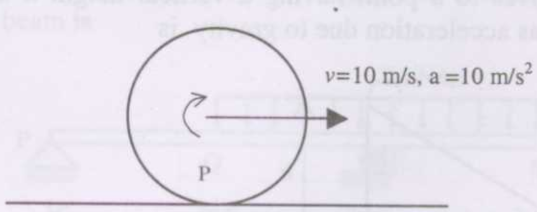
Q.6 A simply supported beam of span L and flexural rigidity EI carries a uniformly distributed load w/unit length. The deflection at the mid span of the beam is

(A) $wL^4/(48EI)$
(B) $5wL^4/(96EI)$
(C) $5wL^4/(384EI)$
(D) $3wL^4/(16EI)$

Q.7 During plastic impact of two bodies, which of the following statement is correct ?

(A) Both energy and momentum are conserved
(B) Energy is not conserved; momentum is conserved
(C) Energy is conserved; momentum is not conserved
(D) Neither energy nor momentum is conserved

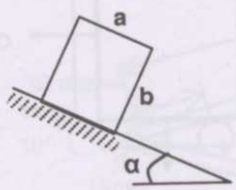
Q.8 A disc of radius 1 m is rolling on the ground without slip as shown below. At a certain instant the center of the disc is moving with a velocity of 10 m/s and an acceleration of $a = +10\ m/s^2$. The magnitude of acceleration of point P on the disc instantaneously touching the ground is



(A) $0.0\ m/s^2$
(B) $10.0\ m/s^2$
(C) $20.0\ m/s^2$
(D) $100.0\ m/s^2$

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

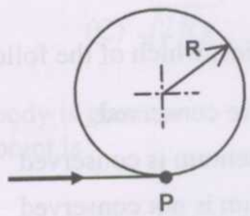
Q.9 A block of length a and height b rests on a rough inclined plane (coefficient of friction μ) as shown below. The angle α, of the inclined plane is slowly increased. The condition that the block will topple due to its own weight before it begins to slide is



(A) $\frac{a}{b} < \mu$ (B) $\frac{a}{b} > \mu$

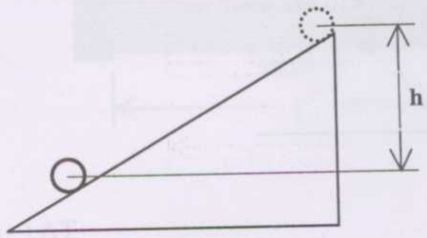
(C) $\frac{a}{b} > \sqrt{1-\mu}$ (D) $\frac{a}{b} < \sqrt{1-\mu}$

Q.10 A particle enters into a smooth frictionless circular loop of radius R, at point P as shown below. If g is the acceleration due to gravity, then the minimum speed with which the particle should enter the circular loop such that it can complete one full circular revolution is



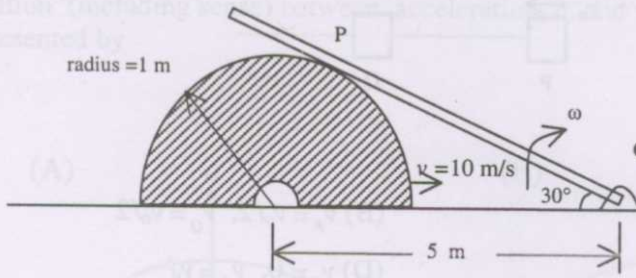
(A) $\sqrt{5Rg}$ (B) $\sqrt{3Rg}$ (C) $\sqrt{2Rg}$ (D) ∞

Q.11 A circular cylinder of radius r and mass m, starts from the top of an inclined plane and rolls down without any slip. After its center moves to a point having a vertical height h as shown below, the velocity of the center of mass, with g as acceleration due to gravity is



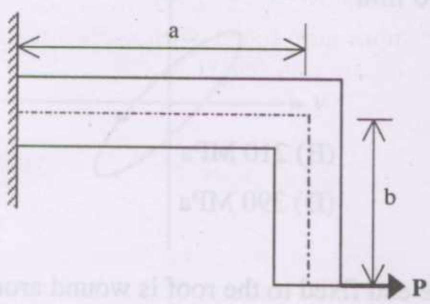
(A) $\sqrt{\frac{gh}{3}}$ (B) $\sqrt{\frac{2gh}{3}}$ (C) $\sqrt{\frac{4gh}{3}}$ (D) $\sqrt{2gh}$

Q.12 Rod PQ, whose end Q is hinged, touches a semi-circular cylinder at point P as shown below. There is no friction between the cylindrical surface and the rod. If the cylinder moves with a constant velocity of 10 m/s in the horizontal direction as shown, then the angular velocity ω of the rod PQ at that instant is



(A) 0.5 rad/s
(B) 1.15 rad/s
(C) 2.0 rad/s
(D) 2.30 rad/s

Q.13 An L-shaped elastic member with flexural rigidity EI is loaded as shown below :



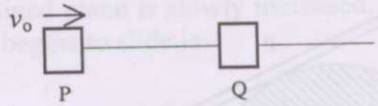
Total strain energy in the member due to bending is:

(A) $P^2b^2(b/_3 + a) / (2EI)$
(B) $P^2b^2(a/_3 + b) / (2EI)$
(C) $P^2a^2(b/_3 + a) / (3EI)$
(D) $P^2a^2(a/_3 + b) / (3EI)$

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

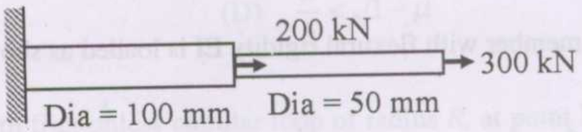
(A) 2 kN m
(B) 1 kN m
(C) 0.75 kN m
(D) 0.25 kN m

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



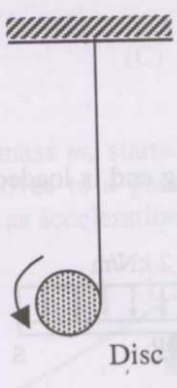
(A) $v_P = -v_o/2,\ v_Q = v_o/2$
(B) $v_P = v_o/2,\ v_Q = v_o/2$
(C) $v_P = 0,\ v_Q = v_o/2$
(D) $v_P = 0,\ v_Q = v_o$

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



(A) 120 MPa
(B) 210 MPa
(C) 153 MPa
(D) 390 MPa

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

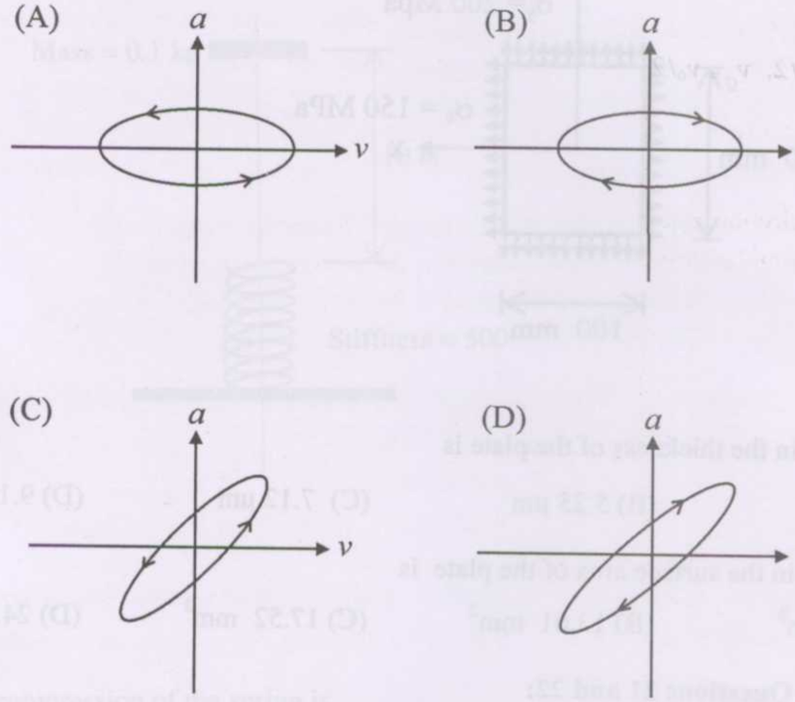


(A) 0 N
(B) 25.0 N
(C) 33.3 N
(D) 50 N

Q.18 A spring-mass system executes SHM in the vertical direction given by the equation

$$\frac{d^2 y}{dt^2} + \omega^2 y = 0$$

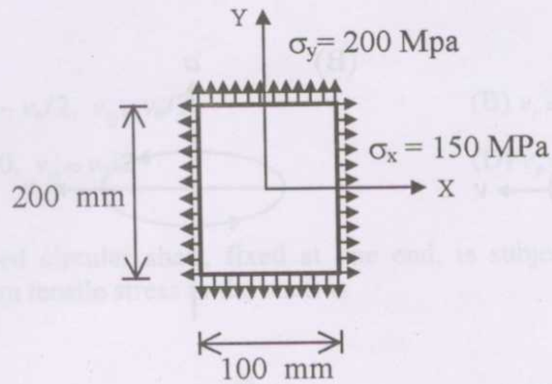
The correct relation (including sense) between acceleration, a, and velocity, v, of the body is graphically represented by



Common Data Questions

Common Data for Questions 19 and 20:

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



Q.19 The change in the thickness of the plate is

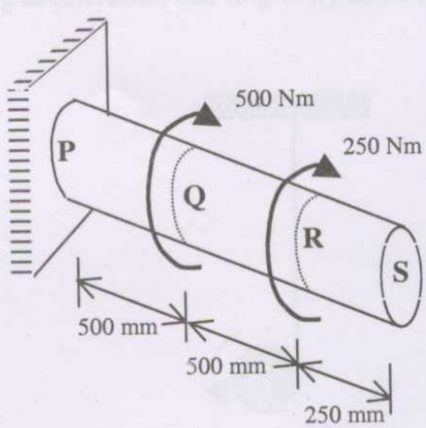
(A) 2.39 μm (B) 5.25 μm (C) 7.12 μm (D) 9.16 μm

Q.20 The change in the surface area of the plate is

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

Common Data for Questions 21 and 22:

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



Q.21 The maximum shear stress due to torsion in the length PQ is

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

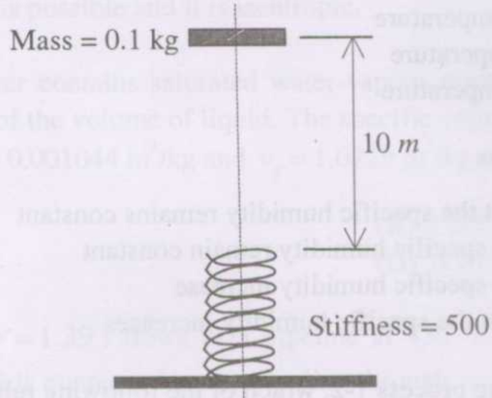
Q.22 The rotation of the free end S due to the torsion is

(A) 0.25° (B) 0.58° (C) 1.22° (D) 1.25°

Linked Answer Questions

Statement for Linked Answer Questions 23 and 24:

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



Q.23 The maximum compression of the spring is

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

Q.24 In the ensuing Simple Harmonic Motion of the body, the magnitude of maximum acceleration is

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

END OF SECTION - D

E : THERMODYNAMICS

Useful data: Universal gas constant, $\bar{R} = 8314$ J/kmol K; $g = 9.8$ m/s^2

Q. 1 – Q. 8 carry one mark each.

Q.1 The ideal gas law is valid for

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

Q.2 During the adiabatic saturation process

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

Q.3 For an ideal gas undergoing a throttling process 1-2, which of the following relationships holds ?

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

Q.4 A Carnot refrigerator operating between –1 °C and 33 °C has a cooling capacity of 1.6 kW. The power consumed by the refrigerator is

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

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

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

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

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

Q.7 On a *T-s* diagram, the slope of the constant volume line for an ideal gas is

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

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

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

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

Q.9 Atmospheric air ($R = 287$ J/kg ; $\gamma = 1.4$) at 1 bar and 25 °C is compressed adiabatically to 2 bar and 105 °C. Which of the following statements is correct ?

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

Q.10 A pressure cooker contains saturated water-vapour mixture at 100 °C with volume of vapour being eight times that of the volume of liquid. The specific volume of saturated liquid and saturated vapour at 100 °C are, $v_f = 0.001044$ m^3/kg and $v_g = 1.6729$ m^3/kg, respectively. The quality of the mixture is

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

Q.11 An ideal gas ($\gamma = 1.39$) flows in a pipeline at 450 °C and 20 bar. A rigid, insulated and initially evacuated vessel is connected to the pipeline through a valve. The valve is now opened and the gas is allowed to fill the empty vessel. The final temperature of the gas in the vessel is

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

Q.12 An equi-molar mixture of nitrogen ($\gamma = 1.4$) and helium ($\gamma = 1.67$) is initially at 5 bar and 300 °C. The mixture is expanded adiabatically to a pressure of 2 bar. The final temperature of the mixture is

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

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

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

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

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

Q.15 The saturation pressures of water at 100 °C and 105 °C are respectively 101.3 kPa and 120.8 kPa. Taking the molecular weight of water as 18, the latent heat of water in kJ/kg at 102.5 °C is approximately equal to

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

Q.16 An engine reversibly receives 1200 J of heat at 900 K. After rejecting heat to the ambient at 300 K, it develops 600 J of work. The irreversibility in joules is equal to

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

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

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

Q.18 A certain quantity of gas undergoes the polytropic process, $P V^{1.3}$ = constant, from an initial state of 1.5 MPa and 0.09 m^3 to the final pressure of 7.5 MPa. The work done by the gas in kJ is

(A) –217 (B) –200 (C) 200 (D) 217

Common Data Questions

Common Data for Questions 19 and 20:

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

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

Q.19 The quality of steam at the exit of the turbine after an isentropic expansion is

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

Q.20 If the steam leaves the turbine as saturated vapour, the power produced by the turbine in kW is

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

Common Data for Questions 21 and 22:

The flow rate of refrigerant R-12 in a refrigerator is 0.03 kg/s. The refrigerant enters the compressor as saturated vapour at 150.9 kPa. After adiabatic compression, it enters the condenser as superheated vapour at 500 kPa and 100 °C and leaves the condenser as saturated liquid at the same pressure. Use the following data to answer the questions 21 and 22.

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

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

Q.21 The refrigeration effect in kW is

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

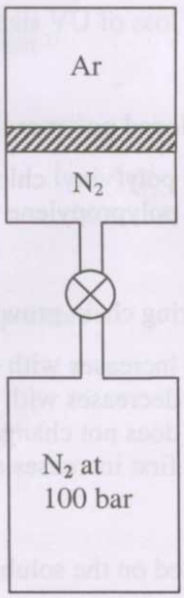
Q.22 The actual power input to the compressor in kW is

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

Linked Answer Questions

Statement for Linked Answer Questions 23 and 24:

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



Q.23 The work done by argon in kJ during the process is

(A) 10 (B) 1.041 (C) – 0.624 (D) –1.041

Q.24 The work done by nitrogen in kJ during the process is

(A) 1.046 (B) 0.629 (C) –1.046 (D) –10

END OF SECTION - E

F : POLYMER SCIENCE AND ENGINEERING

Q. 1 – Q. 8 carry one mark each.

Q.1 Which of the following trends is the most appropriate for a thixotropic fluid ?

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

Q.2 The temperature at which thermoforming is best carried out is

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

Q.3 Which of the following blends is immiscible ?

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

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

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

Q.5 A doped polymer that conducts electricity is

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

Q.6 During chain growth polymerization, the molecular weight of the polymer

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

Q.7 Based on the solubility parameter (δ) the best solvent for polyethylene ($\delta = 16.2$ MPa$^{1/2}$) is

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

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

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

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

Q.9 Pair the items in the Column I with those in the Column II.

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

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

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

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

If a steady shear stress, s_0, is applied, the strain at the steady state, γ_0, is given by

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

Q.11 Match the polymerization initiator with the respective process.

Initiator	***Process***
P. benzyl lithium	1. coordination polymerization
Q. tropylium chloride	2. anionic polymerization
R. AIBN	3. cationic polymerization
S. $TiCl_4/Al(Et)_3$	4. radical polymerization

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

Q.12 Arrange the following polyamides (PA) in decreasing order of their melting points :

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

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

Q.13 Match the characterization technique with the most appropriate property

Characterization technique	***Property***
P. infrared spectroscopy	1. melting point
Q. thermo-gravimetric analysis	2. functional group
R. transmission electron microscopy	3. degradation temperature
S. differential scanning calorimetry	4. morphology

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

Q.14 Match the rubber ingredients with their appropriate function.

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

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

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

(A) $2N_0(M_A + M_B)/N$
(B) $N_0(M_A + M_B)/N$
(C) $N_0(M_A + M_B)/2N$
(D) $N_0^2(M_A + M_B)/N^2$

Q.16 The ratio of the complex dynamic modulus to the storage modulus of a polymer system with a phase angle of $45°$ is

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

Q.17 Match the additive to its most common function.

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

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

Q.18 Match the polymer mechanical property with the appropriate testing method.

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

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

Common Data Questions

Common Data for Questions 19 and 20:

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

Q.19 The modulus of the composite is

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

Q.20 The fibre-matrix bond strength, assuming a critical fibre length of 12 mm, is

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

Common Data for Questions 21 and 22:

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

Q.21 The shear stress exerted by the polymer on the wall of the mold is

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

Q.22 The power consumed by the plasticizing screw is

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

Linked Answer Questions

Statement for Linked Answer Questions 23 and 24:

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

Q.23 The fractional crystallinity of the sample is

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

Q.24 The heat of fusion of the PET crystalline phase is

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

END OF SECTION - F

G : FOOD TECHNOLOGY

Q. 1 – Q. 8 carry one mark each.

Q.1 Among the following amino acids, the one that has a disulfide linkage is

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

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

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

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

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

Q.4 The most suitable evaporator for concentration of fruit juices is

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

Q.5 Souring of milk is primarily due to the conversion of lactose to

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

Q.6 The selective media used for isolating *Escherichia coli* is

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

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

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

Q.8 A cyclone separator is used for the separation of

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

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

Q.9 Match the items in Group I with the most appropriate items in Group II.

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

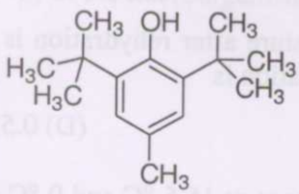
(A) P–3, Q–1, R–2, S–5
(B) P–1, Q–3, R–4, S–5
(C) P–3, Q–1, R–5, S–2
(D) P–1, Q–3, R–5, S–4

Q.10 Two key reactions involved in enzymatic browning of food are

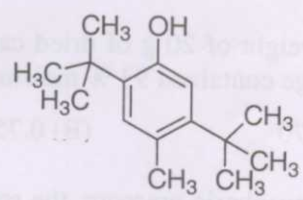
(A) hydroxylation of phenol to *p*-dihydroxybenzene followed by its oxidation to *p*-quinone
(B) oxidation of phenol to *p*-quinone followed by its reduction to *p*-dihydroxybenzene
(C) oxidation of phenol to *o*-quinone followed by its reduction to *o*-dihydroxybenzene
(D) hydroxylation of phenol to *o*-dihydroxybenzene followed by its oxidation to *o*-quinone

Q.11 The correct structure of synthetic antioxidant BHT (butylated hydroxy toluene) is

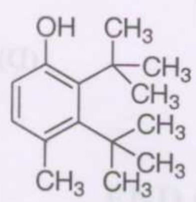
(A)



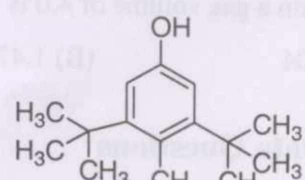
(B)



(C)



(D)



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

(A) 800 kg
(B) 200 kg
(C) 300 kg
(D) 600 kg

Q.13 The correct pair of food borne disease and its causative microorganism is

(A) Hemorrhagic inflammation of intestinal wall – *Camplylobacter jejuni*
(B) Paratyphoid fever – *Staphylococcus aureus*
(C) Typhoid fever – *Solmonella typhimurium*
(D) Listerellosis – *Leptospira biflexa*

Q.14 Fermentation process of vinegar production involves

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

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

(A) $(d_1 + d_2)/2$
(B) $(d_2^2 - d_1^2)/d_1$
(C) $(d_2 - d_1)$
(D) $(d_2^2 - d_1^2)/d_1d_2$

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

Group I	Group II
P. Lag phase	1. Number of viable cells decreases
Q. Exponential phase	2. Growth ceases and population remains constant
R. Stationary phase	3. Preparatory phase for cell division
S. Decline phase	4. Cells divide steadily at constant rate
	5. Cells aggregate

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

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

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

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

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

Common Data Questions

Common Data for Questions 19 and 20:

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

Q.19 The humidity of air (kg water /kg air) is

(A) 0.496
(B) 0.082
(C) 0.018
(D) 0.046

Q.20 The percentage relative humidity of air is

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

Common Data for Questions 21 and 22:

In an ice-cream manufacturing plant, 1450 litres of ice-cream was obtained from 1000 litres of ice-cream mix. The composition of ice-cream mix was as follows:

Fat: 12.0 %, Sugar: 15.0 %, Milk solids not fat: 11.0 %, Stabilizer & emulsifier: 0.3 %.

Q.21 Specific gravity of ice-cream mix at 16 °C is

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

Q.22 Percent over run in the ice-cream was

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

Linked Answer Questions

Statement for Linked Answer Questions 23 and 24:

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

Q.23 The z-value (°C) of the microorganism is

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

Q.24 The TDT value (minutes) at 110 °C is

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

END OF QUESTION PAPER