

METALLURGY ENGINEERING ¹

GATE 2013

EE25BTECH11027-INDHIRESH S

I. Q1 - Q25 CARRY ONE MARK EACH

- 1) Degree and order of the differential equation $\frac{d^2y}{dx^2} + 3\frac{dy}{dx} - 6y = 0$, respectively, are (GATE MT 2013)
- a) 1 and 2 b) 2 and 1 c) 1 and 1 d) 2 and 2
- 2) As the concentration of point defects in a crystal increases, its configurational entropy (GATE MT 2013)
- a) does not change c) increases
b) decreases d) initially increases and then decreases
- 3) In a binary system $A - B$, ϵ_{AA} , ϵ_{BB} and ϵ_{AB} correspond to $A - A$, $B - B$ and $A - B$ bond energies respectively. The miscibility gap will occur if (GATE MT 2013)
- a) $\epsilon_{AB} > \frac{1}{2}(\epsilon_{AA} + \epsilon_{BB})$ c) $\epsilon_{AB} = \frac{1}{2}(\epsilon_{AA} + \epsilon_{BB})$
b) $\epsilon_{AB} < \frac{1}{2}(\epsilon_{AA} + \epsilon_{BB})$ d) $\epsilon_{AB} < \frac{1}{4}(\epsilon_{AA} + \epsilon_{BB})$
- 4) Critical value of the Gibbs energy of nucleation at equilibrium temperature is (GATE MT 2013)
- a) zero b) infinite c) positive d) negative
- 5) With respect to the matrix of Al-Cu alloys, $G - P$ zones are (GATE MT 2013)
- a) coherent c) semi-coherent
b) incoherent d) chemically indistinguishable
- 6) Which one of the following techniques does NOT require quenching to obtain final case hardness? (GATE MT 2013)
- a) Flame hardening c) Nitriding
b) Induction hardening d) Carburizing
- 7) Which one of the following elements is an austenite stabilizer? (GATE MT 2013)

- a) Nitrogen b) Molybdenum c) Vanadium d) Tungsten
- 8) A 0.2wt% plain carbon steel sheet is heated and equilibrated in the inter-critical region followed by instant water quenching. The microstructure of the quenched steel sheet consists of (GATE MT 2013)
- a) fully martensite c) martensite + pearlite
b) proeutectoid ferrite + pearlite d) martensite + austenite
- 9) As compared to the engineering stress-engineering strain curve, the true stress-true strain curve for a given material (GATE MT 2013)
- a) lies above and to the left
b) lies below and to the right
c) crosses the engineering stress-engineering strain curve
d) is identical
- 10) Which one of the following does NOT improve fatigue life of a steel component? (GATE MT 2013)
- a) Nitriding c) Improving surface finish
b) Decarburization d) Shot-peening
- 11) When two phases α and β in an alloy are in thermodynamic equilibrium, then (GATE MT 2013)
- a) $C_p^\alpha = C_p^\beta$ b) $V_m^\alpha = V_M^\beta$ c) $G_m^\alpha = G_m^\beta$ d) $\overline{G}_i^\alpha = \overline{G}_i^\beta$
- 12) Isothermal compressibility of a material is given by (GATE MT 2013)
- a) $-\frac{1}{p}(\frac{\partial V}{\partial p})_T$ b) $\frac{1}{p}(\frac{\partial V}{\partial p})_T$ c) $-\frac{1}{V}(\frac{\partial V}{\partial p})_T$ d) $\frac{1}{V}(\frac{\partial V}{\partial p})_T$
- 13) In the Ellingham diagram for oxides, $C-CO$ line cuts the $M-MO$ line at temperature T_1 and the $M'-M$ line at a higher temperature T_2 . At a temperature greater than T_1 and less than T_2 , carbon can reduce (GATE MT 2013)
- a) MO c) $M'O$
b) both MO and $M'O$ d) neither MO nor $M'O$
- 14) Which one of the following can give information about the corrosion rate? (GATE MT 2013)
- a) Pourbaix diagram c) EMF series
b) Polarization technique d) Galvanic series

15) In a roasting process, the set of conditions that favour sulphate formation from metal sulphide concentrates are

- P) high temperature
- Q) high partial pressure of oxygen
- R) use of excess air
- S) use of excess air

(GATE MT 2013)

- a) *P, R and S*
- b) *P, Q and R*
- c) *Q and S*
- d) *R and S*

16) High top pressure in a blast furnace operation

- a) favours the solution-loss reaction
- b) suppresses the solution-loss reaction
- c) decreases gas-solid contact time
- d) increases coke rate

17) In L-D steelmaking, the final slag can be best described as (GATE MT 2013)

- a) oxidizing
- b) basic
- c) oxidizing and basic
- d) reducing and basic

18) The permeability of burden in an ironmaking blast furnace can be improved by using (GATE MT 2013)

- a) fine charge
- b) agglomerated charge
- c) oxygen enriched air blast
- d) pulverized coal injection through the tuyeres

19) For a good quality brazing, the molten filler alloy should have (GATE MT 2013)

- a) low contact angle with the base metal
- b) low density
- c) high surface tension
- d) high viscosity

20) Risers are NOT required for casting (GATE MT 2013)

- a) stainless steel
- b) plain carbon steel
- c) grey cast iron
- d) white cast iron

21) For scalar fields ϕ and ψ , the value of $\nabla \cdot (\nabla \phi \times \nabla \psi)$ is _____ (GATE MT 2013)

22) The atomic packing fraction of diamond cubic structure is _____ (GATE MT 2013)

23) The total number of possible heat transfer mode(s) is _____ (GATE MT 2013)

- 24) If σ and ϵ are true stress and true strain, respectively, the maximum true uniform strain that can be imparted to a material obeying $\sigma = 1050\epsilon^{0.25}$ is _____
(GATE MT 2013)
- 25) Arc welding is done using current, voltage and welding speed of 200A, 20V and 0.01m/s, respectively. The heat input in kJ per unit length is _____
(GATE MT 2013)

II. Q26 - Q55 CARRY TWO MARKS EACH

- 26) Which one of the following series is divergent? (GATE MT 2013)
- a) $\sum_{n=1}^{\infty} \frac{1}{3^{n-1}}$ b) $\sum_{n=1}^{\infty} \frac{1}{n}$ c) $\sum_{n=0}^{\infty} \frac{1}{2^n}$ d) $\sum_{n=1}^{\infty} \frac{1}{n^n}$
- 27) Taylor series expansion of the function $f(x) = \frac{x}{1+x}$ around $x = 0$ will be
(GATE MT 2013)
- a) $1+x+x^2+x^3+\dots$ b) $1-x+x^2-x^3+\dots$ c) $0+x+\frac{x^2}{2}+\frac{x^3}{3}+\dots$ d) $0+x-x^2+x^3-\dots$
- 28) Which one of the following attributes is NOT correct for the matrix?
(GATE MT 2013)

$$\begin{pmatrix} \cos \theta & -\cos \theta & 0 \\ \sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{pmatrix}, \text{ where } \theta = 60^\circ \quad (1)$$

- a) orthogonal b) singular c) skew-symmetric d) positive-definite
- 29) A unit cell of an element has maximum linear density along the [110] direction. The packing density of its (100) plane is
(GATE MT 2013)
- a) 0.68 b) 0.74 c) 0.79 d) 0.91
- 30) For an FCC metal, the ratio of interplanar spacing obtained from the first two peaks of the X-ray diffraction pattern is
(GATE MT 2013)
- a) 1.91 b) 1.63 c) 1.41 d) 1.15
- 31) There are 150 gearwheels in a box, out of which 112 are within the required tolerance, 21 are below and rest are above the required tolerance. If the selection is done without replacement, the combined probability of randomly selecting a gearwheel below the tolerance and then a second one above the tolerance is
(GATE MT 2013)
- a) 0.016 b) 0.032 c) 0.492 d) 0.984
- 32) Match the metal in Group 1 with its corresponding ore in Group 2 (GATE MT 2013)

Group 1	Group 2
P. Ni	1. Monazite
Q. Th	2. Cassiterite
R. Pb	3. Penlandite
S.Sn	4. Galena

- a) $P - 1, Q - 3, R - 4, S - 2$ c) $P - 3, Q - 1, R - 4, S - 2$
b) $P - 4, Q - 2, R - 3, S - 1$ d) $P - 2, Q - 3, R - 1, S - 4$

33) The yield strength of a polycrystalline metal increases from 100MPa to 145MPa on decreasing the grain size from $64\mu\text{m}$ to $25\mu\text{m}$. The yield strength of this metal (in MPa) having a grain size of $36\mu\text{m}$ is (GATE MT 2013)

- a) 110 b) 125 c) 140 d) 165

34) In a brittle material, the maximum internal crack length is $8\mu\text{m}$. If Young's modulus is 400GPa and surface energy is 3.14J/m^2 , the estimated theoretical fracture strength (in MPa) is (GATE MT 2013)

- a) 375 b) 412 c) 327 d) 447

35) Saturation magnetization of an FCC metal with lattice parameter 0.2nm is 600kA/m . The net magnetic moment per atom is given by (in Bohr magneton)(GATE MT 2013)

- a) 8.08×10^{57} b) 2.02×10^{57} c) 0.517 d) 0.129

36) A 480mm thick slab is hot-rolled using a roll of 720mm diameter. For a coefficient of friction of 0.5, the maximum possible reduction (in mm) is (GATE MT 2013)

- a) 90 b) 180 c) 240 d) 360

37) Match the defects listed in Group I with the corresponding manufacturing process listed in Group II. (GATE MT 2013)

Group 1	Group 2
(P) Orange-peel effect	(1) Extrusion
(Q) Chevron cracking	(2) Deep drawing
(R) Flash	(3) Arc welding
(S) Undercut	(4) Forging

- a) $P - 1, Q - 2, R - 4, S - 3$ c) $P - 3, Q - 4, R - 2, S - 4$
b) $P - 2, Q - 3, R - 1, S - 4$ d) $P - 2, Q - 1, R - 4, S - 3$

38) Match the powder production technique given in Group I with the corresponding shape listed in (GATE MT 2013)

Group 1

- (P) Reduction
(Q) Gas Atomization
(R) Milling
(S) Electrolysis

Group 2

- (1) Flaky
(2) Spongy
(3) Dendritic
(4) Spherical

- a) $P - 2, Q - 4, R - 1, S - 3$
b) $P - 1, Q - 3, R - 2, S - 4$

- c) $P - 2, Q - 3, R - 4, S - 1$
d) $P - 3, Q - 2, R - 1, S - 4$

- 39) Match the suitability of non-destructive testing method in Group I for the detection of defects listed in Group II (GATE MT 2013)

Group 1

- (P) Magnetic particle inspection
(Q) X-ray radiography
(R) Dye penetrant test
(S) Ultrasonic testing

Group 2

- (1) Surface crack in martensitic stainless steels
(2) Surface crack in austenitic stainless steels
(3) Hairline crack in aluminium
(4) Inclusions in steels

- a) $P - 2, Q - 4, R - 3, S - 1$
b) $P - 4, Q - 2, R - 1, S - 3$

- c) $P - 3, Q - 1, R - 2, S - 4$
d) $P - 1, Q - 4, R - 2, S - 3$

- 40) For the following electrochemical reaction $Sn + 2H^+ = Sn^{2+} + H_2$, if the solution has Sn^{2+} concentration 10^{-2} M and pH 5 at 298K, which of the following is true? Given: standard reduction potential for $Sn^{2+} + 2e^- \rightarrow Sn$ is $-0.136V$ versus SHE; $p_{H_2} = 1atm$ (GATE MT 2013)

- a) Sn undergoes oxidation
b) H^+ undergoes reduction

- c) Sn^{2+} undergoes reduction
d) No net reaction

- 41) Match the unit operation in Group I with its corresponding principle in Group II: (GATE MT 2013)

Group 1

- (P) Jigging
(Q) Tabling
(R) Heavy media separation
(S) Flotation

Group 2

- (1) Modification of surface tension
(2) Difference in density
(3) Differential initial acceleration
(4) Differential lateral movement

- a) $P - 3, Q - 4, R - 2, S - 1$
b) $P - 2, Q - 3, R - 1, S - 4$

- c) $P - 4, Q - 2, R - 3, S - 1$
d) $P - 1, Q - 3, R - 2, S - 4$

- 42) Determine the correctness or otherwise of the following Assertion (a) and Reason (r). (GATE MT 2013)

Assertion: For the extraction of metal values from their sulphide concentrates by hydrometallurgical route, leaching with oxygen under high pressure is used.

Reason: Presence of oxygen under high pressure causes roasting of sulphides, which helps in leaching of the values.

- a) a is true but r is false
 b) a is false but r is true
 c) both a and r are true, and r is the reason for a
 d) both a and r are true, but r is not the reason for a
- 43) The aperture size (in μm) of a 200 mesh sieve having a wire diameter of $53\mu\text{m}$ is _____ (GATE MT 2013)
- 44) From a $2\text{m} \times 1.2\text{m}$ sheet, squares are cut out from each of the four corners as shown in the figure and then the sides are bent to form an open box. The maximum possible volume (in m^3) of the box is _____ (GATE MT 2013)

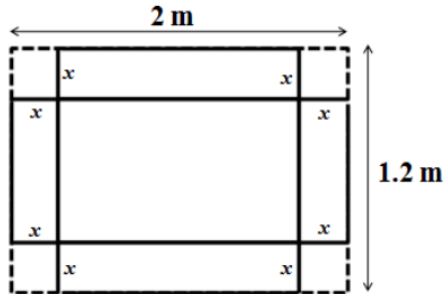


Fig. 44.

CUTTED SHEET

- 45) Applying the secant method, the first approximation to the root of $f(x) = 1 + \ln x + \frac{x}{2}$ starting with function values at $x = 0.3$ and $x = 0.4$, is _____ (GATE MT 2013)
- 46) The critical internal crack length (in mm) in a steel having K_{Ic} of $45\text{MPa}\sqrt{\text{m}}$ to support a Mode-I stress of 400MPa is _____ (GATE MT 2013)
- 47) Ladle deoxidation of liquid steel is done at 1600°C by adding ferro-aluminium. By assuming Stokes law behaviour, time (in s) required for alumina particles of $50\mu\text{m}$ diameter to float to the surface from a depth of 2m would be _____ (GATE MT 2013)

COMMON DATA QUESTIONS

Common Data for Questions 48 and 49:

A steel specimen containing $0.2\text{wt.}\% \text{C}$ is carburized in an atmosphere that maintains a carbon content of $1.2\text{wt.}\% \text{C}$ at the surface of the specimen.

y	erf(y)
0.85	0.7707
0.90	0.7970
0.95	0.8209

48) What is the depth (in μm) from the surface of the specimen at which a composition of 0.4wt.% C is obtained after carburizing at 870°C for 10 h? (GATE MT 2013)

- a) 15 b) 84kg c) 113kg d) 875kg

49) How long (in h) will it take to double the depth at which 0.4wt.%C is reached? (GATE MT 2013)

- a) 40 b) 20 c) 18 d) 14

Common Data for Questions 50 and 51:

Integral enthalpy of mixing (in J/mol) of liquid (Cu, Zn) solution can be approximated by $\Delta H_m^{\text{mix}} = -19250x_{\text{Cu}}x_{\text{Zn}}$

50) The corresponding partial molar enthalpy of mixing (in J/mol) for Cu is (GATE MT 2013)

- a) $19250x_{\text{Zn}}^2$ c) $38500x_{\text{Zn}} - 19250x_{\text{Zn}}^2 - 19250$
b) $-19250x_{\text{Cu}}^2$ d) $-19250x_{\text{Zn}}^2$

51) Assuming regular solution behaviour, the solution parameter (in J/mol) is (GATE MT 2013)

- a) -19250 b) -9625 c) 13.75 d) 2315.4

LINKED ANSWER QUESTIONS

Statement for Linked Answer Questions 52 and 53:

The density and associated crystallinity for two polypropylene samples are as follows:

density, g/cm^3	crystallinity, %
1.20	50
1.44	80

52) Density of totally amorphous polypropylene is (GATE MT 2013)

- a) 0.64 b) 0.74 c) 0.84 d) 0.94

53) The percent crystallinity of polypropylene sample having a density of 1.3g/cm^3 is (GATE MT 2013)

- a) 54 b) 64 c) 74 d) 84

Statement for Linked Answer Questions 54 and 55:

An edge dislocation is present in $\alpha - Fe$. Atomic diameter of iron atom is $0.25nm$ and its shear modulus is $70GPa$.

- 54) Modulus of the Burgers vector (in nm) is (GATE MT 2013)

- a) 0.125 b) 0.25 c) 0.50 d) 0.625

- 55) Energy (in J/m) of the dislocation is (GATE MT 2013)

- a) 0.5×10^{-9} b) 1.1×10^{-9} c) 2.2×10^{-9} d) 4.4×10^{-9}

III. GENERAL APTITUDE (GA) QUESTIONS

Q.56-Q.60 carry one mark each.

- 56) A number is as much greater than 75 as it is smaller than 117. The number is: (GATE MT 2013)

- a) 91 b) 93 c) 89 d) 96

- 57) The professor (1) ordered to(2) the students to go (3) out of the class(4). Which of the above underlined parts of the sentence is grammatically incorrect?

(GATE MT 2013)

- a) 1 b) 2 c) 3 d) 4

- 58) Which of the following options is the closest in meaning to the word given below: Primeval (GATE MT 2013)

- a) Modern b) Historic c) Primitive d) Antique

- 59) Friendship, no matter how _____ it is, has its limitation (GATE MT 2013)

- a) cordial b) intimate c) secret d) pleasant

- 60) Select the pair that best expresses a relationship similar to that expressed in the pair: Medicine: Health

(GATE MT 2013)

- a) Science: Experiment c) Education: Knowledge
b) Wealth: Peace d) Money: Happiness

Q.61 to Q.65 carry two marks each.

- 61) X and Y are two positive real numbers such that $2X + Y \leq 6$ and $X + 2Y \leq 8$. For which of the following values of (X, Y) the function $f(X, Y) = 3X + 6Y$ will give maximum value?

(GATE MT 2013)

- a) $(\frac{4}{3}, \frac{10}{3})$ b) $(\frac{8}{3}, \frac{20}{3})$ c) $(\frac{8}{3}, \frac{10}{3})$ d) $(\frac{4}{3}, \frac{20}{3})$

62) If $|4X - 7| = 5$ then the values of $2|X| - |-X|$ is (GATE MT 2013)

- a) $(2, \frac{1}{3})$ b) $(\frac{1}{2}, 3)$ c) $(\frac{3}{2}, 9)$ d) $(\frac{2}{3}, 9)$

63) Following table provides figures (in rupees) on annual expenditure of a firm for two years - 2010 and 2011.

Category	2010	2011
Raw material	5200	6240
Power and fuel	7000	9450
Salary and wages	9000	12600
Plant and machinery	20000	25000
Advertising	15000	19500
Research and Development	22000	26400

In 2011, which of the following two categories have registered increase by same percentage? (GATE MT 2013)

- a) Raw material and Salary and wages
 b) Salary and wages and Advertising
 c) Power and fuel and Advertising
 d) Raw material and Research and Development

64) A firm is selling its product at Rs.60 per unit. The total cost of production is Rs.100 and firm is earning total profit of Rs.500. Later, the total cost increased by 30%. By what percentage the price should be increased to maintained the same profit level. (GATE MT 2013)

- a) 5 b) 10 c) 15 d) 30

65) Abhishek is elder to Savar.

Savar is younger to Anshul.

Which of the given conclusions is logically valid and is inferred from the above statements?

(GATE MT 2013)

- a) Abhishek is elder to Anshul
 b) Anshul is elder to Abhishek
 c) Abhishek and Anshul are of the same age
 d) No conclusion follows

END OF THE QUESTION PAPER