# GATE -2007 MT

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## Q.1 – Q.20: One mark each

1. The number of boundary conditions required to solve a steady-state two-dimensional diffusion equation ($\nabla^2 C = 0$) is (GATE 2007 MT):

   (a) 1

   (b) 2

   (c) 3

   (d) 4

2. The determinant of the matrix

$$\begin{bmatrix} 1 & 3 & 2 \\ 2 & 6 & 4 \\ -5 & 3 & 1 \end{bmatrix}$$

   is (GATE 2007 MT):

   (a) -10

   (b) -5

   (c) 0

   (d) 5

3. With $\varepsilon$ (true plastic strain) and $n$ (strain-hardening coefficient), necking in a cylindrical tensile specimen of a work-hardened metal occurs when (GATE 2007 MT):

   (a) $\varepsilon = n$

   (b) $\varepsilon = 2n$

   (c) $\varepsilon = n^{0.5}$

   (d) $\varepsilon = n^2$

4. A perfectly plastic metal piece with cross-section $4\,\text{mm} \times 4\,\text{mm}$ and length $25\,\text{mm}$ is stretched to $100\,\text{mm}$. The deformed cross-section is (GATE 2007 MT):

   (a) $1\,\text{mm} \times 1\,\text{mm}$

   (b) $2\,\text{mm} \times 2\,\text{mm}$

   (c) $3\,\text{mm} \times 3\,\text{mm}$

   (d) $4\,\text{mm} \times 4\,\text{mm}$

5. Loading in Mode I fracture refers to (GATE 2007 MT):

(a) Opening mode

(b) Sliding mode

(c) Tearing mode

(d) Twisting mode

6. Cyclones are primarily used for (GATE 2007 MT):

   (a) Comminution

   (b) Concentration

   (c) Dewatering

   (d) Classification

7. A typical collector used in sulphide flotation is (GATE 2007 MT):

   (a) Pine oil

   (b) Potassium ethyl xanthate

   (c) Oleic acid

   (d) Polyacrylamide

8. In a three component system at constant pressure, the maximum number of phases that can coexist at equilibrium is (GATE 2007 MT):

   (a) 2

   (b) 3

   (c) 4

   (d) 5

9. Metal extracted by leaching is (GATE 2007 MT):

   (a) Iron

   (b) Aluminum

   (c) Lead

   (d) Gold

10. In niobium micro-alloyed steel joined by fusion welding, loss of strength in heat affected zone (HAZ) is due to (GATE 2007 MT):

    (a) Precipitate coarsening and grain growth

    (b) Coarse pearlite and grain boundary precipitation

    (c) Tempered martensite and grain boundary carbide

    (d) Bainite formation

11. Primary heat source in cupola melting is (GATE 2007 MT):

    (a) $C + O_2 \rightarrow CO_2$
    (b) $C + H_2O \rightarrow CO + H_2$
    (c) $C + CO_2 \rightarrow 2CO$
    (d) $CaCO_3 \rightarrow CaO + CO_2$

12. Solder wire does not work harden at room temperature because (GATE 2007 MT):

    (a) Dislocations become immobilized
    (b) Grains grow preferentially
    (c) Recrystallization temperature below room temperature
    (d) Grains have preferred orientation

13. Typical cooling rate during atomization is (GATE 2007 MT):

    (a) $10^4$ K/s
    (b) 1 K/s
    (c) $10^4$ K/s
    (d) $10^0$ K/s

14. Fluidity of alloy does not increase with (GATE 2007 MT):

    (a) Superheat
    (b) Channel size
    (c) Flow velocity
    (d) Heat transfer coefficient

15. In polymers, mass averaged molecular weight is (GATE 2007 MT):

    (a) Greater than number averaged molecular weight
    (b) Smaller than number averaged molecular weight
    (c) Equal to number averaged molecular weight
    (d) Unrelated to number averaged molecular weight

16. Alloy system with complete solid solubility is (GATE 2007 MT):

    (a) Cu-Ni
    (b) Fe-Cu
    (c) Pb-Sn
    (d) Cu-Zn

17. Small addition of thoria in tungsten filaments (GATE 2007 MT):

(a) Decreases diffusivity

(b) Enhances boundary mobility

(c) Increases segregation

(d) Limits grain growth

18. Activity of carbon with respect to graphite in iron is (GATE 2007 MT):

(a) 0.5

(b) 0.85

(c) 1.0

(d) 1.5

19. Number of interstitial sites in FCC unit cell are (GATE 2007 MT):

(a) 4 tetrahedral and 8 octahedral

(b) 8 tetrahedral and 4 octahedral

(c) 12 tetrahedral and 4 octahedral

(d) 4 tetrahedral and 4 octahedral

20. Dimension of thermal conductivity is (GATE 2007 MT):

(a) $ML^2T^{-3}\Theta^{-1}$

(b) $MT^{-3}\Theta^{-1}$

(c) $L^2T^{-1}$

(d) $MLT^{-3}\Theta$

21. The configurational entropy $S_c$ in an ideal solid solution is given by

$$S = -R\left(x \ln x + (1-x)\ln(1-x)\right),$$

where $x$ is the mole fraction of solute. The limit $x \to 0$ of $S_c$ is (GATE 2007 MT):

(a) $\infty$

(b) $R \ln 2$

(c) $R$

(d) 0

22. The directions [100] and  in a cubic crystal are coplanar with (GATE 2007 MT):

(a)

(b) [1]

(c)

(d)

23. In a RH degasser, the hydrogen mass balance is given by

$$-W\frac{dC_H}{dt} = R(C_H - C_{H,eq}),$$

where $W = 150$ tons, $C_H$ is hydrogen concentration at time $t$, $C_{H,eq} = 0.5$ ppm, $R$ is circulation rate in tons/min. To reduce hydrogen from 5 ppm to 1 ppm in 20 min, the required $R$ is (GATE 2007 MT):

(a) 10.05
(b) 12.51
(c) 14.73
(d) 16.48

24. Given $\mathbf{V} = (4xy - 3z^3)\mathbf{i} + 2x^2\mathbf{j} - 9xz^2\mathbf{k}$, the divergence of $\mathbf{V}$ is (GATE 2007 MT):

(a) $4xy - 18z$
(b) $4y^2 - 9xz$
(c) $4y - 18xz$
(d) $2xy + 18z^2$

25. The carbon concentration profile in decarburization is given by:

$$C(x,t) = L + M\,\mathrm{erf}\left(\frac{x}{2\sqrt{Dt}}\right),$$

where $x = 0.5\,mm$, $C_{initial} = 1.2\%$, $C_{final} = 0.8\%$, $D = 1.28 \times 10^{-11} m^2/s$. The approximate time $t$ is (GATE 2007 MT):

(a) 30 hours
(b) 3 hours
(c) 3 minutes
(d) 30 seconds

26. The probability distribution function is $p(x) = \frac{1}{\sqrt{\pi}}e^{-x^2}$. Using the trapezoidal rule, the probability that $x$ lies between 0.6 and 0.8 is (GATE 2007 MT):

(a) 0
(b) 0.069
(c) 0.138
(d) 0.56

27. In the TTT diagram for eutectoid steel, the delay at temperatures above 550°C arises due to (GATE 2007 MT):

(a) low driving force

(b) low mobility of dislocations

(c) low vacancy concentration

(d) low diffusivity

28. A cylindrical specimen is elastically deformed; initial length $100\,mm$, diameter $10\,mm$, final length $100.1\,mm$, diameter $9.996\,mm$. Using $E = 200\,GPa$, calculate the shear modulus $G$ ($E = 2G(1+\nu)$) (GATE 2007 MT):

(a) 71.43 GPa

(b) 76.92 GPa

(c) 83.33 GPa

(d) 100.00 GPa

29. Surface energy of a brittle material is doubled without change in modulus. The approximate increase in fracture strength is (GATE 2007 MT):

(a) 100

(b) 73

(c) 50

(d) 41

30. Matching exercise: Match fracture mechanisms with fracture surface morphologies (GATE 2007 MT):

Groups: (P) ductile fracture, (Q) brittle fracture, (R) fatigue fracture

Morphologies: (1) cleavage, (2) dimples, (3) striations, (4) veins

(a) P-4, Q-2, R-3

(b) P-2, Q-1, R-3

(c) P-2, Q-3, R-1

(d) P-4, Q-3, R-2

31. Settling velocity of a $0.5\mu m$ diameter particle (density $4900\,kg/m^3$) in water ($1000\,kg/m^3$), viscosity $1\,cP$ is (GATE 2007 MT):

(a) $53.08 \times 10^{-6}\,m/s$

(b) $40 \times 10^{-6}\,m/s$

(c) $53.08 \times 10^{0}\,m/s$

(d) $106.16 \times 10^{-6}\,m/s$

32. Calculation: The recovery of gold in given flotation data (GATE 2007 MT):

(a) 8.25

(b) 22.26

(c) 85.80

(d) 91.80

33. For a pulp with 65

(a) 72.9

(b) 65

(c) 59.3

(d) 40.7

34. Superplastic deformation depends on which factors (GATE 2007 MT):

P. Extremely fine and uniform grain size Q. High homologous temperature R. High strain rate S. Coarse non-uniform grain size

(a) P, Q

(b) Q, R, S

(c) P, Q, R

(d) Q, R

35. For hot rolling: Roll grooves are made along the roll axis to achieve (GATE 2007 MT):

P. Increase bite angle Q. Decrease rolling load R. Achieve larger reduction S. Decrease roll flattening

(a) P, Q

(b) Q, R

(c) P, R

(d) Q, S

41. The atomic packing factor for the diamond cubic structure is (GATE 2007 MT):

(A) 0.74

(B) 0.68

(C) 0.34

(D) 0.25

42. The maximum amount of proeutectoid austenite that can form in 3.5% C steel (max solubility of C in $\gamma = 2.11\%$) is (GATE 2007 MT):

(A) 24.80%

(B) 36.53%

(C) 67.87%

(D) 72.52%

43. Identify the incorrect statement with reference to LD steel making (GATE 2007 MT):

(A) The temperature of the LD furnace is maintained at around 1600°C

(B) The basicity of slag is maintained at around unity

(C) Dephosphorization and decarburization proceed simultaneously

(D) High silicon hot metal may lead to slopping

44. Match the processes in Group I with products in Group II (GATE 2007 MT)

Table 1: Process-Product Matching

| **Group I (Processes)** | | **Group II (Products)** | |
|---|---|---|---|
| P | Czochralski process | 1 | Single crystal of GaAs |
| Q | Calendaring | 2 | Hypoeutectic Al-Si alloy |
| R | Pultrusion | 3 | Vinyl floor tile |
| S | Thixocasting | 4 | Polymer matrix composite |

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

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

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

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

45. Match the applications in Group I with materials in Group II (GATE 2007 MT)

Table 2: Application-Material Matching

| **Group I (Applications)** | | **Group II (Materials)** | |
|---|---|---|---|
| P | Electric motor cores | 1 | $\gamma$-$Fe_2O_3$ particles |
| Q | Credit card stripe | 2 | Barium titanate |
| R | Permanent magnet | 3 | $Co_5Sm$ intermetallic |
| S | Multilayer capacitors | 4 | Grain-oriented silicon steel |

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

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

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

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

46. Match the phases in Group I with the descriptions in Group II (GATE 2007 MT)

Table 3: Phase-Description Matching

| **Group I (Phases)** | | **Group II (Descriptions)** | |
|---|---|---|---|
| P | $\varepsilon$-Carbide | 1 | Eutectic in cast iron |
| Q | Sigma phase | 2 | Embrittling in stainless steel |
| R | $\delta$-Ferrite | 3 | Tempered carbide |
| S | Steadite | 4 | Magnetic weld deposit |

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

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

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

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

47. Match the materials in Group I with the bond types in Group II (GATE 2007 MT)

Table 4: Material-Bond Type Matching

| **Group I (Materials)** | | **Group II (Bond Types)** | |
|---|---|---|---|
| P | Silicon | 1 | Metallic |
| Q | Copper | 2 | Covalent |
| R | Sodium chloride | 3 | Ionic |
| | | 4 | van der Waals |

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

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

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

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

48. The activation energy for a reaction is 100 kJ/mol. The approximate increase in temperature required to double the reaction rate (from 25°C) is (GATE 2007 MT):

(A) 5°C

(B) 10°C

(C) 15°C

(D) 20°C

49. For the reaction $2Fe + \frac{3}{2}O_2 = Fe_2O_3$ with standard free energy $\Delta G^\circ$, the approximate pressure for dissociation of $Fe_2O_3$ at 1100°C is (GATE 2007 MT):

    (A) $1.0 \times 10^{-20}$ atm

    (B) $1.46 \times 10^{-12}$ atm

    (C) $2.3 \times 10^{7}$ atm

    (D) $3.55 \times 10^{-15}$ atm

50. Identify the incorrect statement related to unit processes in extractive metallurgy (GATE 2007 MT):

    (A) Selective distillation is a purification technique used in extractive metallurgy

    (B) Coking of coal is carried out in a shaft furnace

    (C) Precipitation is a hydrometallurgy route of purification

    (D) Predominance area diagram is used to select operating conditions of roasting

51. Identify the correct statement with reference to blast furnace iron making (GATE 2007 MT):

    (A) Hematite is reduced to magnetite in the lower part of the shaft

    (B) Coke rate cannot be improved by oil injection through tuyere

    (C) High exit gas temperature may indicate "channeling"

    (D) Pressure drop in blast furnace cannot be improved by proper burden distribution

52. Match the processes in Group I with their descriptions in Group II (GATE 2007 MT):

Table 5: Process-Description Matching

| **Group I (Processes)** | | **Group II (Descriptions)** | |
|---|---|---|---|
| P | COREX process | 1 | Decarburization of liquid steel |
| Q | OBM process | 2 | Steelmaking using oxygen |
| R | Carbonyl process | 3 | Nickel refining |
| S | AOD process | 4 | Alternative route of liquid iron |

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

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

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

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

53. The process of cementation involves (GATE 2007 MT):

    (A) Separation of the desired metal by adding a more reactive metal

(B) Elimination of a more reactive metal by preferential oxidation

(C) Refining by preferential dissolution in organic solvent

(D) Extraction by selective dissolution in inorganic solvent

54. Identify the incorrect statement (GATE 2007 MT):

(A) A concentration gradient in the electrolyte may lead to galvanic cell formation

(B) Chromium is added to improve oxidation resistance of stainless steels

(C) Cathodic protection can be provided by applying a coating

(D) A steel bolt or nut is permissible on a large copper vessel

55. Nanoparticles have a higher surface atom fraction $f_s$ compared to bulk $f_0$. The ratio $(f_s/f_0)$ varies with the particle size $r$ as (GATE 2007 MT):

(A) $r^{-3}$

(B) $r^{-2}$

(C) $r^{-1}$

(D) $r^2$

56. The theoretical shear strength of dislocation-free single crystal aluminium ($G = 28$ GPa) is approximately (GATE 2007 MT):

(A) 28.0 GPa

(B) 4.5 GPa

(C) 0.56 GPa

(D) 0.07 GPa

57. The equilibrium vacancy concentration in copper is 588 ppm at 1000°C and 134 ppm at 800°C. The molar enthalpy of vacancy formation is (GATE 2007 MT):

(A) 49 kJ/mol

(B) 84 kJ/mol

(C) 168 kJ/mol

(D) 243 kJ/mol

58. In a cubic crystal, which dislocation reaction is vectorially correct and energetically feasible (GATE 2007 MT)?

(A) $[\bar{1}11] + [111] \rightarrow a$

(B) $+ \rightarrow$

(C) $+ \rightarrow$

(D) $\rightarrow +$

59. The mechanical response of an elastomer is characterized by (GATE 2007 MT):

(A) Increase in elastic modulus with increasing temperature

(B) Large recoverable strains

(C) Decrease in elastic modulus with increasing temperature

(D) Adiabatic decrease in temperature on stretching

60. Which of the following statements are true about edge dislocations (GATE 2007 MT)?

(A) Do not have an extra half plane

(B) Burgers vector is perpendicular to the line direction

(C) Can avoid obstacles by cross-slip

(D) Parallel edge dislocations of opposite sign can attract or repel depending on geometry

61. A structural component in the form of a very wide 10 mm thick plate is to be fabricated from 4340 steel. If the design stress level is 50% of the yield strength, the critical flaw size is (Yield strength = 1515 MPa, $K_{IC}$ = 60.4 MPa$\sqrt{\text{m}}$, Geometry factor $Y = 1$) (GATE 2007 MT):

(A) 1.0 mm

(B) 2.0 mm

(C) 3.0 mm

(D) 4.0 mm

62. The tensile yield strength of a ductile metal is 100 MPa. If the material is subjected to tensile stresses $\sigma_2 = \sigma_3 = 50$ MPa along the other principal directions, the material yields when (GATE 2007 MT):

(A) $\sigma_1 = 50$ MPa in compression or 150 MPa in tension

(B) $\sigma_1 = 50$ MPa in compression or 50 MPa in tension

(C) $\sigma_1 = 100$ MPa in tension

(D) $\sigma_1 = 0$

63. Match the energy gaps in Group I with the materials in Group II (GATE 2007 MT):

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

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

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

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

Table 6: Energy Gap and Material Matching

| Group I (Energy Gaps) | | Group II (Materials) | |
|---|---|---|---|
| P | Diamond | 1 | 0.1 eV |
| Q | Silicon | 2 | 0.7 eV |
| R | Gray Tin | 3 | 1.1 eV |
| | | 4 | 6.0 eV |

Table 7: Term-Description Matching

| Group I (Terms) | | Group II (Descriptions) | |
|---|---|---|---|
| P | Hall-Petch Effect | 1 | Solute-dislocation interaction |
| Q | Bauschinger Effect | 2 | Dislocation multiplication |
| R | Cottrell atmosphere | 3 | Grain boundary strengthening |
| | | 4 | Barrelling under compression |
| | | 5 | Mechanical hysteresis during plasticity |

64. Match the terms from Group I to their descriptions in Group II (GATE 2007 MT):

(A) P-3, Q-5, R-1

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

(C) P-5, Q-1, R-2

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

65. Enthalpy of formation at 298 K, $\Delta H$, of $CO_2$ and PbO are $-393$ kJ mol$^{-1}$ and $-220$ kJ mol$^{-1}$ respectively. The enthalpy change for $2PbO + C \rightarrow 2Pb + CO_2$ is (GATE 2007 MT):

(A) $-173$ kJ

(B) 15 kJ

(C) 47 kJ

(D) 440 kJ

66. In normalized hypoeutectoid plain carbon steels, how do the fraction of proeutectoid ferrite ($f$) and yield strength ($\sigma_y$) change with increasing carbon (GATE 2007 MT):

(A) $f$ increases and $\sigma_y$ decreases

(B) both $f$ and $\sigma_y$ increase

(C) both $f$ and $\sigma_y$ decrease

(D) $f$ decreases and $\sigma_y$ increases

67. Identify the correct statement about manganese in steels (GATE 2007 MT):

(A) it decreases hardenability

(B) it makes the steel susceptible to hot-shortness

(C) it is a strong austenite stabilizer

(D) it decreases hardness of martensite

68. When one mole of copper is quenched from 1000 K to 300 K, the amount of heat released is (specific heat $C_p = 22.68 + 6.3 \times 10^{-3}T$ J/mol·K):

(A) 9.37 kJ

(B) 15.87 kJ

(C) 18.74 kJ

(D) 22.68 kJ

69. A suitable technique for monitoring a growing crack in an alloy is (GATE 2007 MT):

(A) Acoustic emission

(B) Radiography

(C) Magnetic particle technique

(D) Liquid penetrant test