METALLURGY ENGINEERING

GATE 2009
EE25BTECH11027-INDHIRESH S

I. Q1 - Q20 CARRY ONE MARK EACH

1) In a $n \times n$ identity matrix, the trace equals: (GATE MT 2009)

a) 0 b) 1 c) n d) n^2

2) Gibbs free energies of a system in states 1 and 2 are denoted by G_1 and G_2 respectively. The system will go spontaneously from state 1 to state 2 , if and only if: (GATE MT 2009)

a) $G1 - G2 > 0$ b) $G1 - G2 < 0$ c) $G1 - G2 = 0$ d) $G1 < 0, G2 < 0$

3) Flux in welding process acts as: (GATE MT 2009)

a) catalyst
b) protective agent
c) filler
d) heat generator

4) In an ideal HCP packing , the $\frac{c}{a}$ ratio is: (GATE MT 2009)

a) 1.225 b) 1.414 c) 1.633 d) 1.732

5) A property that CANNOT be obtained from a tensile test is (GATE MT 2009)

a) Young's modulus
b) yield strength
c) ultimate tensile strength
d) endurance limit

6) Intensive thermodynamic variables are (GATE MT 2009)

a) independent of the number of moles in the system
b) dependent on the volume of the system
c) dependent on the volume of the system
d) dependent on the volume of the system

7) In a sound casting , the last liquid to solidify is in the (GATE MT 2009)

a) runner b) riser c) gate d) vent

8) An annealed plain carbon steel, showing fully pearlitic microstructure , has a carbon content of (GATE MT 2009)

a) $0.001wt\%$ b) $0.20wt\%$ c) $0.77wt\%$ d) $1.20wt\%$

9) Superalloys are (GATE MT 2009)

a) Al-based alloys
b) Cu-based alloys
c) Ni-based alloys
d) Mg-based alloys

10) Wood is naturally occurring (GATE MT 2009)

a) malleable material
b) composite material
c) ceramic material
d) isotropic material

11) The function, $f(x) = ax^2 + bx + c$ has a maximum only if (GATE MT 2009)

a) $a < o$ b) $a > 0$ c) $a = 0$ d) $a > 0$ and $b < 0$

12) A furnace wall consists of four layers of different materials $M1, M2, M3$ and $M4$. If the layers are of equal thickness and the steady state temperature profile is, as shown below , then the material with the lowest thermal conductivity is (GATE MT 2009)

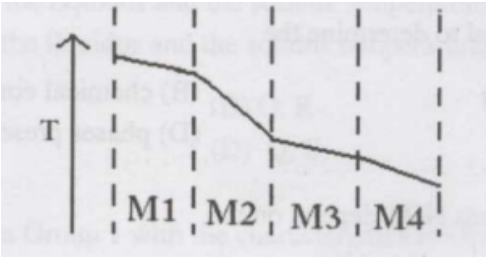

Fig. 12.

STUDY STATE TEMPERATURE PROFILE

a) $M1$ b) $M2$ c) $M3$ d) $M4$

13) From the list given below

P) Cu
Q) Mg
R) Ni
S) Zn

two metals which provide cathodic protection to steel are (GATE MT 2009)

a) P,R b) R,S c) Q,R d) Q,S

14) The Miller indices of the plane PQRS, shown in the unit cell are (GATE MT 2009)

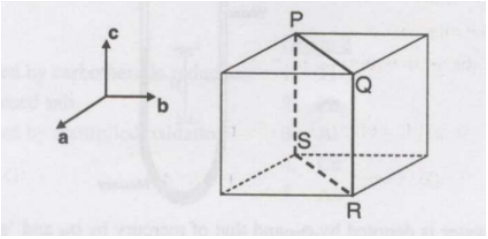

Fig. 14.

THE UNIT CELL

a) 111 b) 121 c) 110 d) 100

15) A defect that is bounded by two mirror plane is (GATE MT 2009)

a) twin b) stacking fault c) grain boundry d) edge dislocation

16) $\lim_{x\to 0} \frac{sinx}{x}$ is equal to (GATE MT 2009)

a) 0 b) 1 c) ∞ d) undefined

17) Fick's first law relates (GATE MT 2009)

a) flux of atoms and the concentration gradient
b) amount of gas dissolved in the molten metal and the partial pressure
c) applied normal stress and the orientation of slip system
d) heat flux and the temperature gradient

18) X-ray radiography is used to determine the (GATE MT 2009)

a) soundness of casting c) crystal structure
b) chemical composition d) phase present

19) Hardenability of steel does NOT depend on the (GATE MT 2009)

a) alloy content c) amount of carbon present
b) grain size d) amount of cold work

20) p-type semiconductor can be obtained by doping silicon with (GATE MT 2009)

a) antimony b) phosphorous c) arsenic d) boron

II. Q21 - Q60 CARRY 2 MARKS EACH

21) The figure below shows water over mercury manometer. if the density of water is denoted by ρ_w and that of mercury by ρ_M and $'g'$ denotes the acceleration due to gravity , the pressure difference $(P_A - P_B)$ will be equal to (GATE MT 2009)

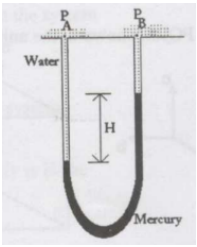

Fig. 21.

MERCURY MANOMETER

a) $-(\rho_M g H)$ b) $(\rho_W - \rho_M)$gH c) rho_MgH d) $(\rho_M - \rho_W)$gH

22) Match the processes given in Group 1 with the coresponding typical defects given in group 2 (GATE MT 2009)

Group 1	Group 2
P.Forging	1. Alligatoring
Q.Rolling	2.Cold shut
R.Deep drawing	3.Chevron cracks
S.Extrusion	4. wrinkles

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

23) From the list given below , two factors that promotes coring in cast alloys are (GATE MT 2009)

P) slow cooling during solidification
Q) rapid cooling during solidification
R) small difference between the liquids and solidus temperatures
S) large difference between the liquidus and solidus temperatures

a) P,R b) Q,R c) P,S d) Q,S

24) Match the loading conditions in group 1 with the characteristics in group 2. (GATE MT 2009)

Group 1	Group2
P.Tensile	1.barreling
Q.Compressive	2. Intergranular cracking
R.Fatigue	3. striations
S.Creep	4.Cup and cone
	5.Earing

a) $P-4, Q-5, R-3, S-1$
b) $P-4, Q-1, R-3, S-2$
c) $P-5, Q-1, R-4, S-2$
d) $P-1, Q-2, R-3, S-5$

25) Match the extraction methods in group 1 with the metals in group 2 (GATE MT 2009)

Group 1	Group 2
P. roasting followed by carbothermic reduction	1. Ti
Q. electrolysis of fused salt	2.Pb
R. roasting followed by controoled oxidation	3.Al
S. halide process	4. Cu
	5. Au

a) $P-2, Q-3, R-4, S-1$
b) $P-5, Q-4, R-3, S-1$
c) $P-2, Q-5, R-1, S-4$
d) $P-3, Q-2, R-5, S-1$

26) The average molecular weight of high density polyethylene is found to be 56000.The degree of polymerization is (GATE MT 2009)

a) 200 b) 1000 c) 2000 d) 4000

27) A $0.2wt\%$ C steel is carburized at $1200K$ for 4 hours to obtain $0.8wt\%$ at a depth of $0.20mm$. Instead , if the carburizing is performed for 8 hours at the same temperature , then $0.8wt\%$ C will be acheived at a depth of (GATE MT 2009)

a) $0.23mm$ b) $0.55mm$ c) $0.28mm$ d) $0.40mm$

28) A unit dislocation with a Burgers vector $\mathbf{b_1}$ will dissociate into two partial dislocations with burgers vectors $\mathbf{b_2}$ and $\mathbf{b_3}$, if and only if (GATE MT 2009)

P) $\mathbf{b_1^2} > \mathbf{b_2^2} + \mathbf{b_3^2}$
Q) $\mathbf{b_1^2} < \mathbf{b_2^2} + \mathbf{b_3^2}$
R) $\mathbf{b_1^2} = \mathbf{b_2^2} + \mathbf{b_3^2}$
S) $\mathbf{b_1^2} \neq \mathbf{b_2^2} + \mathbf{b_3^2}$

a) P,R b) P,S c) Q,R d) Q,S

29) The solution function $y = f(x)$ for the ordinary differential equation, $\frac{dy}{dx} = 3x^2 - 2x$, passes through $(1, 1)$. The magnitude of y at $x = 3$ is (GATE MT 2009)

a) 0 b) 18 c) 19 d) 21

30) What is the magnitude of the following integral using single step application of trapezoid rule? (GATE MT 2009)

$$\int_0^2 (3x^2 + 4x - 2)dx \tag{1}$$

a) 9 b) 16 c) 18 d) 36

31) During a sheet stamping operation, it is observed that sheet surface area triples . the true thickness strain is (GATE MT 2009)

a) -1.1 b) -0.333 c) $+0.333$ d) $+1.1$

32) Match the practices in Group 1 with reactors in Group 2. (GATE MT 2009)

Group 1	Group 2
P. Layered charging of coke and ore	1. Ladle furnace
Q. Oxygen injection through supersonic nozzle	2. Electric arc furnace
R. Aluminium wire feeding	3. Blast furnace
S.Foamy slag practice	4.LD converter

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

33) For the reaction,

$$MO(Pure, Solid) + CO(gas) \longrightarrow M(Pure, Solid) + CO_2(gas)$$

the equilibrium constant at $1000K$ is 2.0. The oxide, MO, can be reduced to M at $1000K$, using a gas mixture containing (GATE MT 2009)

a) $20\%CO, 45\%CO_2, 35\%N_2$
b) $20\%CO, 10\%CO_2, 70\%N_2$
c) $20\%O_2, 80\%N_2$
d) $50\%N_2, 50\%Ar$

34) Stacking fault energy (SFE) plays an important role in determining the work hardening ability of a metal. In this context, the correct logical sequence is (GATE MT 2009)

a) High SFE $\longrightarrow$ easy cross-slip $\longrightarrow$ low work hardening
b) High SFE $\longrightarrow$ difficult cross-slip $\longrightarrow$ high work hardening
c) Low SFE $\longrightarrow$ easy cross-slip $\longrightarrow$ low work hardening
d) Low SFE $\longrightarrow$ difficult cross-slip $\longrightarrow$ low work hardening

35) Match the joining processes in Group 1 with the filler materials in Group 2 (GATE MT 2009)

Group 1	Group 2
P. Soldering	1.Silver- Titanium alloy
Q. Welding	2. Silver- tin alloy
R. Brazing	3.Mild steel
	4. Lead floride

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

36) Match the properties in Group 1 with the metals in Group 2. (GATE MT 2009)

Group 1	Group 2
P. Ferromagnetism	1. Nb
Q. Superconductivity	2. Fe
R. Diamagnetism	3. Cu
S.antiferromagnetism	4. Cr

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

37) Assertion a :During hardening of steel, the component to be heat treated is strongly agitated in the quenching medium.
Reason r: The agitation breaks down the vapour barrier allowing the quench to proceed at a more rapid rate. (GATE MT 2009)

a) Both a and r are correct, but r is not the correct reason for a.
b) Both a and r are false.
c) a is true but r is false.
d) Both a and r are correct and r is the correct reason for a.

38) The activity of copper in the $'impurecopper'$ is 0.5 at $298K$. The minimum voltage required to refine $'impurecopper'$ to pure copper using an electrolyte having Cu^2+ ions at $298K$ is (GATE MT 2009)

a) $0.9mV$ b) $9mV$ c) $90mV$ d) $900mV$

39) A $3.0mm$ diameter single crystal is loaded to $400N$ along [001] direction. The resolved shear stress on $(111)[T01]$ slip system is (GATE MT 2009)

a) $5.8MPa$ b) $11.5MPa$ c) $23.1MPa$ d) $46.2MPa$

40) As per the TTT diagram, bainite will form in eutectoid plain carbon steel when heated to $850^{\circ}C$ followed by (GATE MT 2009)

a) air-cooling to room temperature
b) isothermal holding between eutectoid temperature and the nose
c) quenching to room temperature
d) isothermal holding between the nose and the M, temperature

41) The vapour pressure of pure liquid B at temperature T_o is $0.5atm$. The partial pressure of B in the vapour phase that is in equilibrium with the liquid solution consisting of $30mol\%$ A and $70mol\%$ B at temperature T_O is (assume both liquid and vapour phases behave ideally)

(GATE MT 2009)

a) $0.35atm$ b) $0.50atm$ c) $0.70atm$ d) $1.00atm$

42) During low temperature plastic deformation of an under-aged precipitation hardened alloy, dislocations (GATE MT 2009)

a) climb to completely avoid the precipitate
b) loop around the precipitate
c) cross-slip to completely avoid the precipitate
d) cut through the precipitate

43) According to Hume-Rothery rules, extensive solid solubility between elements X and Y is promoted by the two factors in the following list: (GATE MT 2009)

P) Same crystal structure of X and Y
Q) Large atomic size difference (> 20%) between X and Y
R) Same valence of X and Y
S) Large difference in melting points of X and Y

a) P, Q b) P, R c) Q, S d) P, S

44) At constant temperature and pressure, two phases α and β will be in equilibrium when (GATE MT 2009)

a) chemical potential of each component is the same in α and β
b) partial molar free energy of each component is NOT the same in α and β
c) Gibbs free energy of mixing is minimum
d) enthalpy of mixing is zero

45) The stress applied on a material is (GATE MT 2009)

$$\sigma_{ij} = \begin{pmatrix} 21 & 0 & 0 \\ 0 & 21 & 0 \\ 0 & 0 & 21 \end{pmatrix} \text{MPa} \quad (2)$$

The maximum shear stress experienced by it is

a) $0MPa$ b) $10.5MPa$ c) $21MPa$ d) $63MPa$

46) For the following reaction at 300 K,

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

the heat of reaction is $803kJ/mol$ of CH_4. At $300K$, CH_4 - air gas mixture containing the required stoichiometric amount of oxygen is burnt to completion. Assuming, air contains $20vo1\%O_2$ and $80vol\%N2$ and the specific heats for CO_2, H_2O (g) and N_2 are $50, 40$ and $40J$mol K respectively the adiabatic flame temperature will be (GATE MT 2009)

a) $1684K$ b) $1784K$ c) $2084K$ d) $2384K$

47) Match the properties in Group 1 with the testing techniques in Group 2. (GATE MT 2009)

Group 1	Group 2
P. Electrical conductivity	1. Jominy test
Q. Impact energy	2. Izod test
R. Thermal expansion	3. Dilatometry
S. Specific heat	4. Four probe technique
	5. Differential scanning calorimetry

a) $P-4, Q-2, R-5, S-1$
b) $P-5, Q-3, R-2, S-1$
c) $P-2, Q-1, R-3, S-4$
d) $P-4, Q-2, R-3, S-5$

48) A blast furnace is charged with pure Fe_2O_3. For each ton of Fe produced, it discharges $700kg$ of CO_2 and $450kg$ of CO as top gas. The O_2 consumed, per ton of Fe produced, is (GATE MT 2009)

a) $138kg$ b) $238kg$ c) $338kg$ d) $438kg$

49) Taylor series can be used to approximate the value of $f(x) = \cos x$ by expanding around $x = 0$. If only the first three terms of the series are considered, the magnitude of deviation from the actual value of $\cos(\frac{\pi}{3})$ will be (GATE MT 2009)

a) 0.01 b) 0.03 c) 0.05 d) 0.07

50) A $200mm \times 200mm$ cross-section bloom is continuously cast at a casting speed of $0.05m/s$. The amount of heat extracted from the $0.7m$ long mould is $1.28MW$. Assume that the temperature of the steel is at its melting point while entering and leaving the mould. Latent heat of fusion for the steel is $278kJ/kg$ and density of steel is $7800kg/m^3$. The thickness of the solidified shell emerging from the mould will be (GATE MT 2009)

a) $0.147mm$ b) $1.47mm$ c) $14.7mm$ d) $147mm$

Common data questions

Common data for questions 51 and 52:

A metallic rod with $2mm \times 2mm$ square cross-section is being tested in tension and has the following mechanical properties:

Young's modulus = $100GPa$ Poisson's ratio = 0.30
Yield stress = $500MPa$ Work hardening exponent = 0.25
Ultimate tensile strength = $1000MPa$

51) The rod is loaded to $1000N$, the magnitude of transverse strain is (GATE MT 2009)

a) 0.025% b)) 0.075% c) 0.15% d) 0.25%

52) The modulus of resilience of the material is (GATE MT 2009)

a) $0.25MJ/m^3$ b) $0.50MJ/m^3$ c) $0.75MJ/m^3$ d) $1.25MJ/m^3$

Common data for Questions 53 and 54:

Schematic of the Pb-Sn phase diagram at atmospheric pressure is shown below.

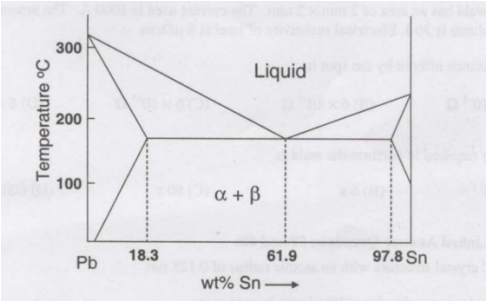

Fig. 52.

Pb-Sn PHASE DIAGRAM AT ATMOSPHERIC PRESSURE

53) A Pb-Sn hypo-eutectic alloy is slowly cooled from the liquid state to room temperature. The composition of the alloy whose microstructure consists of 25*wt%* lamellar constituent is (GATE MT 2009)

a) $Pb - 29.2wt\%\ Sn$ c) $Pb - 40.8wt\%\ Sn$
b) $Pb - 35.5wt\%\ Sn$ d) $Pb - 61.9wt\%\ Sn$

54) The minimum and maximum degrees of freedom in the above binary system are (GATE MT 2009)

a) 1 and 3 b) 0 and 3 c) 1 and 2 d) 0 and 2

Common Data for Questions 55 and 56:

An operator in a steel plant wants to reduce the phosphorous level in steel by treating it with an appropriate slag. The equilibrium phosphorous distribution ratio between slag and liquid steel, i.e. (wt% of P in slag) / (wt% of P in steel) is 100 for the chosen slag composition. Assume before the treatment, the steel contains $0.2wt\%\ P$.

55) If the operator treats $1000kg$ of liquid steel with $100kg$ of slag, the resulting phosphorous content in liquid steel will be (GATE MT 2009)

a) 0.001% b) 0.002% c) 0.010% d) 0.018%

56) Instead, the operator treats the $1000kg$ of liquid steel with $50kg$ of slag. Then, the processed slag is removed and another $50kg$ of fresh slag is added. The resulting phosphorous content in steel will be

(GATE MT 2009)

a) 0.0015% b) 0.0030% c) 0.0055% d) 0.0090%

Linked Answer Questions

Statement for Linked Answer Questions 57 and 58:

In automobile industry, electrical resistance welding is used for spot welding steel panels, each of 1.5mm thickness. The weld has an area of $2mm \times 2mm$. The current used is 1000A. The amount of heat required to melt this spot volume is 36J. Electrical resistivity of steel is 8$\mu\Omega cm$.

57) The resistance offered by the spot is (GATE MT 2009)

a) $6 \times 10^{-8}\Omega$ b) $6 \times 10^{-5}\Omega$ c) $6 \times 10^{+5}\Omega$ d) $6 \times 10^{+8}\Omega$

58) The time required to perform the weld is (GATE MT 2009)

a) 0.6s b) 6s c) 60s d) 600s

Statement for Linked Answer Questions 59 and 60:

Copper has FCC crystal structure with an atomic radius of 0.128nm.

59) The interplanar spacing for (220) planes in copper is (GATE MT 2009)

a) 0.064nm b) 0.128nm c) 0.181nm d) 0.256nm

60) In an X-ray diffraction experiment, radiation of wavelength 0.154nm is used. Assuming the order of reflection to be 1, the Bragg angle for the (220) set of planes in copper will be

(GATE MT 2009)

a) 12.56° b) 36.98° c) 48.98° d) 74.21°

END OF THE QUESTION PAPER