## METALLURGY ENGINEERING 1

## GATE 2009 EE25BTECH11027-INDHIRESH S

I. Q1 - Q20 carry one mark each

2) Gibbs free energies of a system in states 1 and 2 are denoted by  $G_1$  and  $G_2$ 

c) n

(GATE - MT2009)

d)  $n^2$ 

1) In a  $n \times n$  identity matrix, the trace equals:

b) 1

a) 0

	respectively. The system will go spontaneously from state 1 to if:			state $2$ , if and only $(GATE - MT2009)$
	a) $G1 - G2 > 0$	b) $G1 - G2 < 0$	c) G1-G2=0	d) $G1 < 0, G2 < 0$
3)	Flux in welding pro	ocess acts as:		(GATE-MT2009)
	<ul><li>a) catalyst</li><li>b) protective agent</li></ul>		<ul><li>c) filler</li><li>d) heat generator</li></ul>	
4)	In an ideal HCP page	cking, the c/a ratio is	:	(GATE-MT2009)
	a) 1.225	b) 1.414	c) 1.633	d) 1.732
5)	A property that CA	NNOT be obtained fro	om a tensile test is	(GATE - MT2009)
	<ul><li>a) Young's modulus</li><li>b) yield strength</li></ul>		<ul><li>c) ultimate tensile st</li><li>d) endurance limit</li></ul>	rength
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)		the last liquid to soli		(GATE-MT2009)
	a) runner	b) riser	c) gate	d) vent
8)	An annealed plain content of	earbon steel, showing f	ully pearlitic microstr	ucture, has a carbon (GATE – MT2009)

- a) 0.001*wt*%
- b) 0.20wt%
- c) 0.77wt%
- d) 1.20wt%

9) Superalloys are

(GATE - MT2009)

- a) Al-based alloys
- b) Cu-based alloys

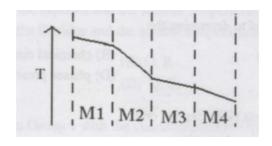
- c) Ni-based alloys
- d) Mg-based alloys
- 10) Wood is naturally occurring

(GATE - MT2009)

- 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 MT2009)

- 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 - MT2009)



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

13) From the list given below 2025

P.Cu

Q.Mg

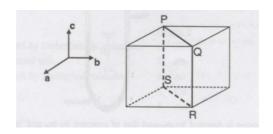
R.Ni

S.Zn

two metals which provide cathodic protection to steel are

(GATE - MT2009)

- a) P.R
- b) R,S
- c) Q,R
- d) O,S
- 14) The Miller indices of the plane PQRS, shown in the unit cell are(GATE MT2009)



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

15) A defect that is bounded by two mirror plane is

(GATE - MT2009)

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

16)  $\lim_{x\to 0} \frac{\sin x}{x}$  is equal to

(GATE - MT2009)

a) 0

b) 1

c) ∞

d) undefined

17) Fick's first law relates

- (GATE MT2009)
- 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 - MT2009)

a) soundness of casting

c) crystal structure

b) chemical composition

- d) phase present
- 19) Hardenability of steel does NOT depend on the
  - a) alloy content

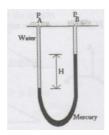
c) amount of carbon present

b) grain size

- d) amount of cold work
- 20) p-type semiconductor can be obtained by doping silicon with (GATE MT2009)
  - 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  $\rho_W$  and that of mercury by  $\rho_M$  and 'g' denotes the acceleration due to gravity, the pressure difference  $(P_A - P_B)$  will be equal to (GATE - MT2009)



- a)  $-(\rho_M gH)$
- 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 (GATE - MT2009)in group 2

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, O-2, R-3, S-4
- c) P-2, O-1, R-3, S-4

b) P-2, O-1, R-4, S-3

- 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 - MT2009)

P.slow cooling during solidification

Q.rapid cooling during solidification

R.small difference between the liquids and solidus temperatures

- a) P,R
- b) Q,r
- c) P.s

- d) Q,s
- 24) Match the following conditions in group 1 with the characteristics in group 2. (GATE - MT2009)

Group2 Group 1 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 - MT2009)

Group 2

1. Ti

2.Pb

3.A1

4. Cu5. Au

(GATE - MT2009)

c) P-2, Q-5, R-1, S-4

d) P-3, Q-2, R-5, S-1

	a) 200	b) 1000	c) 2000	d) 4000	
27)	0.20mm . Instead , if	carburized at 1200K f the carburizing is perf ll be acheived at a dep	formed for 8 hours at t	_	
	a) 0.23 <i>mm</i>	b) 0.55 <i>mm</i>	c) 0.28mm	d) 0.40mm	
28)	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 $(GATE-MT2009)$ 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 $(GATE - MT2009)$					
	a) 0	b) 18	c) 19	d) 21	
30) What is the magnitude of the following integral using single step appication of trapezoid rule? $\int_0^2 (3x^2 + 4x - 2)dx$ ( <i>GATE – MT</i> 2009)					
	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 $(GATE - MT2009)$					

Group 1

P. roasting followed by carbothermic reduction

Q. electrolysis of fused salt

R. roasting followed by controoled oxidation

S. halide process

26) The average molecular weight of high density polyethylene is found to be 56000. The

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

b) P-5, Q-4, R-3, S-1

degree of polymerization is

(GATE - MT2009)

a) -1.1	b) -0.333	c) $+0.333$	d) +1.1		
P. 1	ctices in Group 1 with Group 1 Layered charging of co gen injection through st R. Aluminium wire f S.Foamy slag prac	oke and ore upersonic nozzle eeding	Group 2  1. Ladle furnace 2. Electric arc furnace 3. Blast furnace 4.LD converter		
<ul><li>a) P-3,Q-1,R-2</li><li>b) P-2,Q-4,R-3</li></ul>		c) P-4,Q-3, d) P-3,Q-4,			
33) For the reaction, $MO(Pure, Solid) + CO(gas) \longrightarrow M(Pure, Solid) + CO2 (gas)$ the equilibrium constant at 1000 K is 2.0. The oxide, MO, can be reduced to M at 1000 K, using a gas mixture containing $(GATE - MT2009)$					
	5% CO2, 35% <i>N</i> <sub>2</sub> % <i>CO</i> 2, 70% N2	c) 20% <i>O</i> 2, d) 50% N2.			
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 ( <i>GATE - MT</i> 2009)					
<ul> <li>a) High SFE → easy cross-slip → low work hardening</li> <li>b) High SFE → difficult cross-slip → high work hardening</li> <li>c) Low SFE → easy cross-slip → low work hardening</li> <li>d) Low SFE → difficult cross-slip → low work hardening</li> </ul>					
35) Match the joining processes in Group 1 with the filler materials in Group 2 $(GATE - MT2009)$					
	Group 1 P. Soldering Q. Welding R. Brazing	Group 2 1.Silver- Titaniur 2. Silver- tin a 3.Mild stee 4. Lead flori	ılloy l		
a) P-2, Q-3, R b) P-1, Q-2, R		<ul><li>c) P-3, Q-1</li><li>d) P-2, Q-4</li></ul>			

36) Match the properties in Group 1 with the metals in Group 2.

Group 1

P. Ferromagnetism

Q. Superconductivity

R. Diamagnetism

S.antiferromagnetism

Group 2

1. Nb

2. Fe

3. Cu

4. Cr

(GATE - MT2009)

d) Both a and r are correct and r is the correct reason for a.				
38) The activity of copper in the 'impure copper' is 0.5 at 298 K. The minimum voltage required to refine 'impure copper' to pure copper using an electrolyte having				
$Cu^2$ +ions at 29	8 K 18		(GATE - MT2009)	
a) 0.9 <i>mV</i>	b) 9 <i>mV</i>	c) 90 <i>mV</i>	d) 900mV	
39) A 3.0mm diameter single crystal is loaded to 400 N along [001] direction. resolved shear stress on (111) [T01] slip system is (GATE – MT2				
a) 5.8 MPa	b) 11.5 MPa	c) 23.1 MPa	d) 46.2 MPa	
40) As per the TT heated to 850°C	_	ill form in eutectoid	plain carbon steel when (GATE - MT2009)	
<ul><li>a) air-cooling to room temperature</li><li>b) isothermal holding between eutectoid temperature and the nose</li><li>c) quenching to room temperature</li></ul>				
<ul> <li>d) isothermal holding between the nose and the M, temperature</li> <li>41) The vapour pressure of pure liquid B at temperature To is 0.5 atm. The partial pressure of B in the vapour phase that is in equilibrium with the liquid solution consisting of 30 mol%A and 70 mol% B at temperature T<sub>O</sub> is (assume both liquid and vapour phases behave ideally)</li> </ul>				
phases semare	(acany)		(GATE - MT2009)	
a) 0.35 <i>atm</i>	b) 0.50atm	c) 0.70atm	d) 1.00 <i>atm</i>	
<ul> <li>42) During low temperature plastic deformation of an under-aged precipitation hardened alloy, dislocations (GATE - MT2009)</li> <li>a) climb to completely avoid the precipitate</li> </ul>				
<ul><li>b) loop around the precipitate</li><li>c) cross-slip to completely avoid the precipitate</li><li>d) cut through the precipitate</li></ul>				
43) According to Hume-Rothery rules, extensive solid solubility between elements X and Y is promoted by the two factors in the following list: $(GATE - MT2009)$				

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

a) Both a and r are correct, but r is not the correct reason for a.

Reason r: The agitation breaks down the vapour barrier allowing the quench to

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

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

agitated in the quenching medium.

proceed at a more rapid rate.

b) Both a and r are false.c) a is true but r is false.

R. Same valence of X and Y S. Large difference in melting points of X and Y c) Q, S a) P, Q b) P, R d) P, S 44) At constant temperature and pressure, two phases  $\alpha$  and  $\beta$  will be in equilibrium when (GATE - MT2009)a) (A) chemical potential of each component is the same in $\alpha$  and  $\beta$ b) (B) partial molar free energy of each component is NOT the same in  $\alpha$  and  $\beta$ c) (C) Gibbs free energy of mixing is minimum d) (D) enthalpy of mixing is zero 45) The stress applied on a material is (GATE - MT2009)[21 0 0 | MPa. The maximum shear stress experienced by it is a) 0*MPa* b) 10.5*MPa* c) 21*MPa* d) 63*MPa* 46) For the following reaction at 300 K,  $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ the heat of reaction is 803 kJ/mol of CH<sub>4</sub>. At 300 K, CH<sub>4</sub> - air gas mixture containing the required stoichiometric amount of oxygen is burnt to completion. Assuming, air contains 20 vo1% $O_2$  and 80 vol% $N_2$  and the specific heats for  $CO_2$ ,  $H_2O$  (g) and  $N_2$  are 50, 40 and 40 J mol K- respectively the adiabatic flame temperature will be (GATE - MT2009)a) 1684*K* b) 1784*K* c) 2084*K* d) 2384K 47) Match the properties in Group 1 with the testing techniques in Group 2. (GATE - MT2009)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

P. Same crystal structure of X and Y

O. Large atomic size difference >20% between X and Y

b) P-5, Q-3, R-2, S	S-1	d) P-4, Q-2, R-3, S	S-5	
48) A blast furnace is c 700 kg of $CO_2$ ar produced, is			produced, it discharges sumed, per ton of Fe (GATE – MT2009)	
a) 138kg	b) 238kg	c) 338kg	d) 438kg	
		s of the series are con	= $\cos x$ by expanding sidered, the magnitude $(GATE - MT2009)$	
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 0.05 m/s. The amount of heat extracted from the 0.7 m long mould is 1.28 MW. 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 278 kJ/kg and density of steel is 7800 $kg/m^3$ . The thickness of the solidified shell emerging from the mould will be $(GATE - MT2009)$				
a) 0.147 <i>mm</i>	b) 1.47 <i>mm</i>	c) 14.7mm	d) 147mm	
	Common d	ATA 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 = 100 GPa Poisson's ratio = 0.30 Yield stress = 500 MPa Work hardening exponent = 0.25 Ultimate tensile strength = 1000 MPa 51) The rod is loaded to 1000 N, the magnitude of transverse strain is (GATE - MT2009)				
a) 0.025%	b) ) 0.075%	c) 0.15%	d) 0.25%	
52) The modulus of re	silience of the materia	al is	(GATE - MT2009)	
a) $0.25 \text{ MJ/}m^3$	b) $0.50 \text{ MJ/}m^3$	c) $0.75 \text{ MJ/}m^3$	d) $1.25 \text{ MJ/}m^3$	
· ·	Questions 53 and 54: Pb-Sn phase diagram a		re is shown below.	

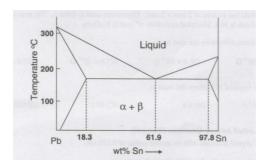
53) A Pb-Sn hypo-eutectic alloy is slowly cooled from the liquid state to room temperature. The composition of the alloy whose microstructure consists of 25wt%

(GATE - MT2009)

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

a) P-4, Q-2, R-5, S-1

lamellar constituent is



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 MT2009)
  - 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 0.2 wt% P.

- 55) If the operator treats 1000 kg of liquid steel with 100 kg of slag, the resulting phosphorous content in liquid steel will be (GATE MT2009)
  - a) 0.001%
- b) 0.002%
- c) 0.010%
- d) 0.018%
- 56) Instead, the operator treats the 1000 kg of liquid steel with 50 kg of slag. Then, the processed slag is removed and another 50 kg of fresh slag is added. The resulting phosphorous content in steel will be

(GATE - MT2009)

- 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 1.5 mm thickness. The weld has an area of  $2mm \times 2mm$ . The current used is 1000 A. The amount of heat required to melt this spot volume is 36 J. Electrical resistivity of steel is  $8\mu\Omega cm$ .

57) The resistance offered by the spot is

(GATE - MT2009)

58) The time requ	(GATE - MT2009)		
a) 0.6 <i>s</i>	b) 6 <i>s</i>	c) 60s	d) 600s
,	Linked Answer Question CC crystal structure wi		f 0.128nm
	ar spacing for (220) pla		
a) 0.064 <i>nm</i>	b) 0.128 <i>nm</i>	c) 0.181 <i>nm</i>	d) 0.256 <i>nm</i>
Assuming the	order of reflection to b		length 0.154 <i>nm</i> is used. for the (220) set of planes
in copper wil	i be		(GATE - MT2009)
a) 12.56°	b) 36.98°	c) 48.98°	d) 74.21°

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

\*END OF THE QUESTION PAPER\*