



collegebatch.com

click to campus

## GATE 2024 Metallurgical Engineering (MT) Question Paper

Graduate Aptitude Test in Engineering (GATE)

Download more GATE Previous Year Question Papers: [Click Here](#)

## General Aptitude (GA)

### Q.1 – Q.5 Carry ONE mark Each

Q.1 If '→' denotes increasing order of intensity, then the meaning of the words [dry → arid → parched] is analogous to [diet → fast → \_\_\_\_\_]. Which one of the given options is appropriate to fill the blank?

- (A) starve
- (B) reject
- (C) feast
- (D) deny

Q.2 If two distinct non-zero real variables  $x$  and  $y$  are such that  $(x + y)$  is proportional to  $(x - y)$  then the value of  $\frac{x}{y}$

- (A) depends on  $xy$
- (B) depends only on  $x$  and not on  $y$
- (C) depends only on  $y$  and not on  $x$
- (D) is a constant

Q.3 Consider the following sample of numbers:

9, 18, 11, 14, 15, 17, 10, 69, 11, 13

The median of the sample is

(A) 13.5

(B) 14

(C) 11

(D) 18.7

Q.4 The number of coins of ₹1, ₹5, and ₹10 denominations that a person has are in the ratio 5:3:13. Of the total amount, the percentage of money in ₹5 coins is

(A) 21%

(B)  $14\frac{2}{7}\%$

(C) 10%

(D) 30%

Q.5 For positive non-zero real variables  $p$  and  $q$ , if

$$\log (p^2 + q^2) = \log p + \log q + 2 \log 3 ,$$

then, the value of  $\frac{p^4 + q^4}{p^2 q^2}$  is

- (A) 79
- (B) 81
- (C) 9
- (D) 83

GATE 2024

**Q.6 – Q.10 Carry TWO marks Each**

Q.6 In the given text, the blanks are numbered (i)–(iv). Select the best match for all the blanks.

Steve was advised to keep his head \_\_\_\_\_ (i) \_\_\_\_\_ before heading \_\_\_\_\_ (ii) \_\_\_\_\_ to bat; for, while he had a head \_\_\_\_\_ (iii) \_\_\_\_\_ batting, he could only do so with a cool head \_\_\_\_\_ (iv) \_\_\_\_\_ his shoulders.

- (A) (i) down (ii) down (iii) on (iv) for
- (B) (i) on (ii) down (iii) for (iv) on
- (C) (i) down (ii) out (iii) for (iv) on
- (D) (i) on (ii) out (iii) on (iv) for

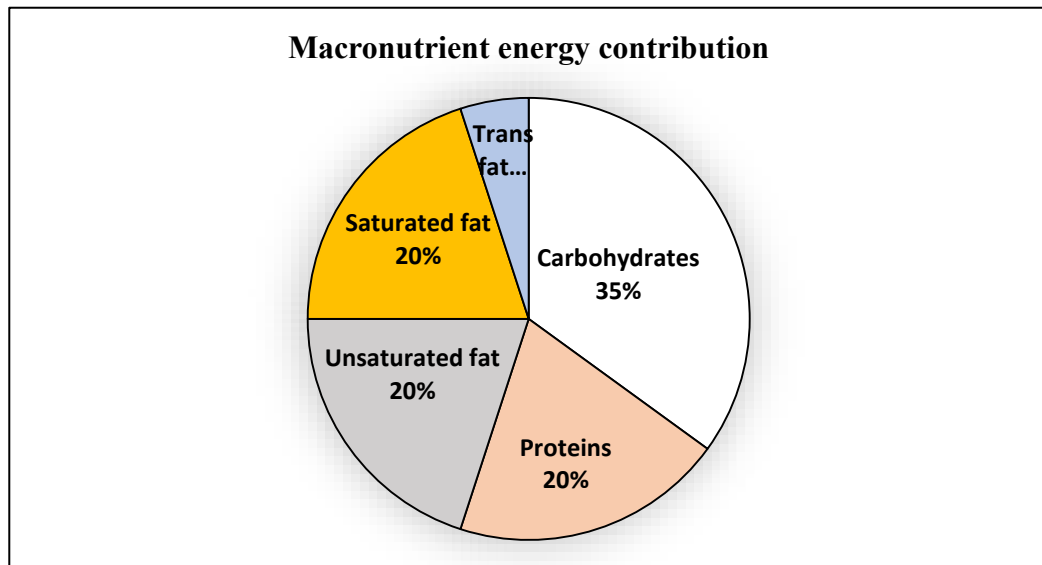
- Q.7 A rectangular paper sheet of dimensions  $54 \text{ cm} \times 4 \text{ cm}$  is taken. The two longer edges of the sheet are joined together to create a cylindrical tube. A cube whose surface area is equal to the area of the sheet is also taken.

Then, the ratio of the volume of the cylindrical tube to the volume of the cube is

- (A)  $1/\pi$   
(B)  $2/\pi$   
(C)  $3/\pi$   
(D)  $4/\pi$

GATE 2024

- Q.8 The pie chart presents the percentage contribution of different macronutrients to a typical 2,000 kcal diet of a person.



The typical energy density (kcal/g) of these macronutrients is given in the table.

Macronutrient	Energy density (kcal/g)
Carbohydrates	4
Proteins	4
Unsaturated fat	9
Saturated fat	9
Trans fat	9

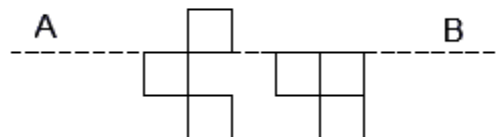
The total fat (all three types), in grams, this person consumes is

- (A) 44.4
- (B) 77.8
- (C) 100
- (D) 3,600

Q.9 A rectangular paper of  $20 \text{ cm} \times 8 \text{ cm}$  is folded 3 times. Each fold is made along the line of symmetry, which is perpendicular to its long edge. The perimeter of the final folded sheet (in cm) is

- (A) 18
- (B) 24
- (C) 20
- (D) 21

Q.10 The least number of squares to be added in the figure to make AB a line of symmetry is



- (A) 6
- (B) 4
- (C) 5
- (D) 7



**Q.11 – Q.35 Carry ONE mark Each**

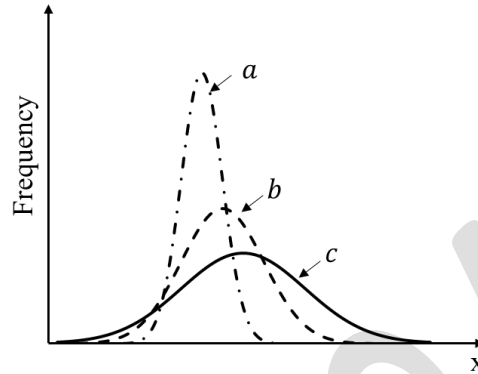
Q.11 If  $X_1$  and  $X_2$  are independent normally distributed random variables with means  $\mu_1$  and  $\mu_2$ , and variances  $\rho_1$  and  $\rho_2$ , respectively, then the combination  $X = X_1 + X_2$  has mean  $\mu$  and variance  $\rho$  such that

- (A)  $\mu = \mu_1 + \mu_2$  and  $\rho = \rho_1 + \rho_2$
- (B)  $\mu^2 = \mu_1^2 + \mu_2^2$  and  $\rho = \rho_1 + \rho_2$
- (C)  $\mu = \mu_1 + \mu_2$  and  $\rho^2 = \rho_1^2 + \rho_2^2$
- (D)  $\mu^2 = \mu_1^2 + \mu_2^2$  and  $\rho^2 = \rho_1^2 + \rho_2^2$

Q.12 Which one of the following is the Taylor-series expansion of  $\ln\left(\frac{1+x}{1-x}\right)$  about the origin for  $|x| < 1$ ?  $x$  is a real number.

- (A)  $x - \frac{x^2}{2} + \frac{x^3}{3} - \dots$
- (B)  $2\left(x - \frac{x^2}{2} + \frac{x^3}{3} - \dots\right)$
- (C)  $x + \frac{x^3}{3} + \frac{x^5}{5} + \dots$
- (D)  $2\left(x + \frac{x^3}{3} + \frac{x^5}{5} + \dots\right)$

Q.13 Consider the normal (Gaussian) distributions  $a, b, c$  shown in the figure.



$\sigma_p$  and  $\mu_p$  are the standard deviation and mean of a distribution  $p$ , respectively, and the means are positive. Which one of the following deductions is correct?

- (A)  $\sigma_a < \sigma_b < \sigma_c$
- (B)  $\sigma_a > \sigma_b > \sigma_c$
- (C)  $\mu_a = \mu_b = \mu_c$
- (D)  $\mu_a > \mu_b > \mu_c$

Q.14 If in an A-B solid solution, the activity and mole fraction of A are given by  $a_A$  and  $X_A$ , respectively, then the activity coefficient of A is given by

(A)  $\frac{a_A}{X_A}$

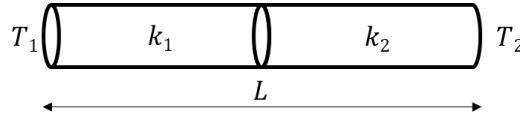
(B)  $\frac{X_A}{a_A}$

(C)  $a_A X_A$

(D)  $a_A X_A^2$

GATE 2024

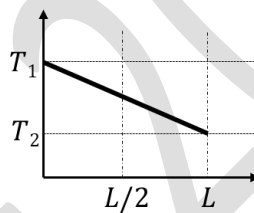
- Q.15 As shown in the figure, two rods of different metals of equal lengths,  $\frac{L}{2}$ , diameter  $d$  ( $d \ll L$ ), and constant thermal conductivities  $k_1$  and  $k_2$  (with  $k_1 > k_2$ ) are connected perfectly (i.e., zero interface thermal resistance).



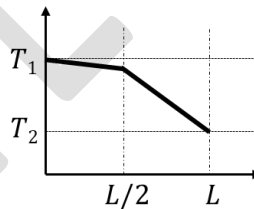
The left and right ends of the connected rod are maintained at temperatures  $T_1$  and  $T_2$  ( $T_1 > T_2$ ). Assume that the rods are insulated from the environment, apart from the two flat ends.

Which one of the following graphs represents the temperature distribution at steady-state? The thickest line shows the temperature profile. The horizontal axis shows the distance from the left end of the rod to the right and the vertical axis denotes temperature.

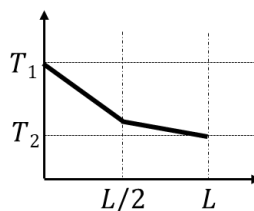
(A)



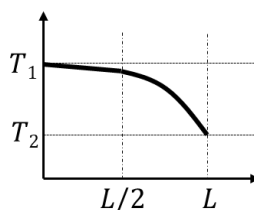
(B)



(C)



(D)



Q.16 Match the laws listed in **Column I** with the corresponding material properties listed in **Column II**

**Column I**

(P) Hooke's law

(Q) Fick's law

(R) Fourier's law

(S) Darcy's law

**Column II**

(1) Thermal conductivity

(2) Young's modulus

(3) Permeability

(4) Diffusivity

(A) P – 2, Q – 1, R – 4, S – 3

(B) P – 4, Q – 3, R – 1, S – 2

(C) P – 2, Q – 4, R – 1, S – 3

(D) P – 4, Q – 3, R – 2, S – 1

Q.17 Wet high intensity magnetic separators (WHIMS) are used to concentrate

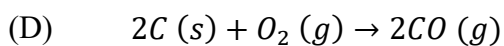
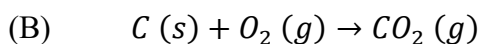
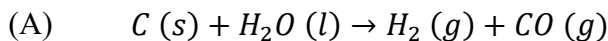
- (A) fine ( $< 75 \mu m$ ) paramagnetic minerals.
- (B) coarse ( $> 75 \mu m$ ) ferromagnetic minerals.
- (C) coarse ( $> 75 \mu m$ ) paramagnetic minerals.
- (D) fine ( $< 75 \mu m$ ) ferromagnetic minerals.

Q.18 Which one of the following reagents is **NOT** used in froth flotation process?

- (A) Lixiviants
- (B) Collectors
- (C) Activators
- (D) Depressants

Q.19 Which one of the following reactions is the Boudouard's reaction?

Given: (s): solid, (l): liquid; (g): gas



Q.20 Which one of the following processes is **NOT** related to the extraction and refining of titanium from ilmenite ore?

(A) Pidgeon's process

(B) Sorel process

(C) Van Arkel process

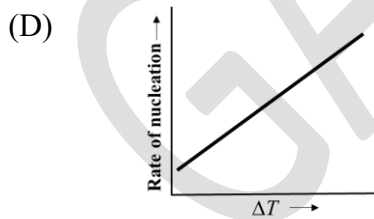
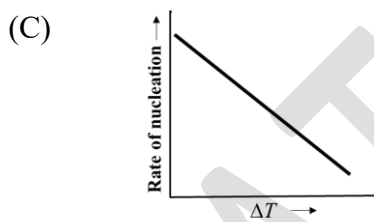
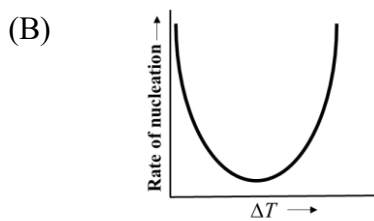
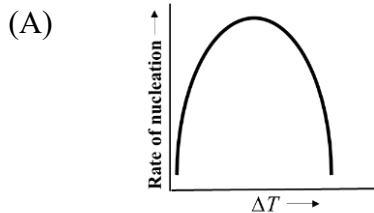
(D) Kroll's process

Q.21 Which one of the following is the correct statement about the industrial production of aluminium from pure dry alumina by Hall-Héroult electrolytic reduction?

- (A) Cell is operated at a high voltage (220 to 240 V) with a very low current density.
- (B) Cell is operated at a low voltage (5 to 7 V) with a very low current density.
- (C) Cell is operated at a high voltage (220 to 240 V) with a very high current density.
- (D) Cell is operated at a low voltage (5 to 7 V) with a very high current density.



Q.22 Which one of the following schematics represents the variation of the rate of nucleation of solid from a pure liquid metal as a function of undercooling ( $\Delta T = T_m - T$ , where  $T_m$  and  $T$  are the freezing temperature and the liquid temperature, respectively)?

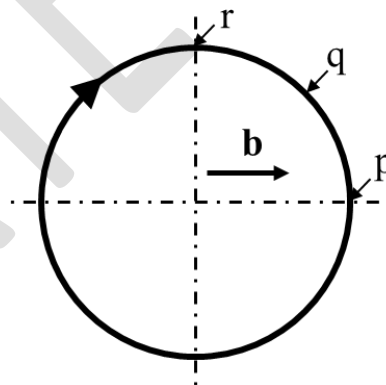


Q.23 Which one of the following crystal structure changes occurs during the transformation of mild steel from austenite to martensite?

- (A) Face centered cubic to body centered cubic
- (B) Face centered cubic to body centered tetragonal
- (C) Body centered cubic to body centered tetragonal
- (D) Body centered tetragonal to face centered cubic

Q.24 The figure shows a dislocation loop (shown by the solid circle), whose Burgers vector is  $\mathbf{b}$  (shown by the horizontal arrow inside the dislocation loop). Identify the nature of the dislocation segment at locations p, q and r.

The dash-dot lines show the horizontal and vertical diameters of the loop, and the arrow along the dislocation loop indicates the line vector.



- (A) p: pure edge, q: mixed, r: pure screw
- (B) p: pure edge, q: pure screw, r: pure edge
- (C) p: pure screw, q: mixed, r: pure screw
- (D) p: pure screw, q: pure edge, r: pure screw

Q.25 Match the concepts listed in **Column I** with the phenomena listed in **Column II**.

**Column I**

P. Peierls-Nabarro stress

Q. Cottrell's atmosphere

R. Paris law

S. Considère's criterion

**Column II**

1. Yield point phenomenon

2. Fatigue

3. Dislocation glide

4. Onset of necking

(A) P – 1, Q – 2, R – 3, S – 4

(B) P – 4, Q – 1, R – 2, S – 3

(C) P – 3, Q – 1, R – 2, S – 4

(D) P – 3, Q – 4, R – 2, S – 1

Q.26 Match the defects listed in **Column I** with the associated manufacturing processes listed in **Column II**.

**Column I**

P. Misrun

Q. Earing

R. Alligatoring

S. Chevron cracking

**Column II**

1. Extrusion

2. Rolling

3. Casting

4. Deep drawing

(A) P – 3, Q – 1, R – 2, S – 4

(B) P – 3, Q – 4, R – 2, S – 1

(C) P – 2, Q – 4, R – 3, S – 1

(D) P – 1, Q – 3, R – 2, S – 4

Q.27 Which one of the following processes is **NOT** involved in the sintering of a green compact of ceramic powders? Assume that sintering is performed without application of external pressure.

(A) Pore shrinkage

(B) Dynamic recrystallization

(C) Lattice diffusion

(D) Grain boundary diffusion

Q.28 Which of the following statements is/are correct for a square matrix  $A$  with real number entries?

$A^T$  denotes the transpose of  $A$  and  $A^{-1}$  denotes the inverse of  $A$ .

- (A)  $A$  is symmetric if  $A^T = -A$ .
- (B)  $A$  is skew-symmetric if  $A^T = -A$ .
- (C) If  $A$  is orthogonal, then  $A^T = A^{-1}$ .
- (D) If  $A$  is orthogonal, then its determinant is zero.

Q.29 Which of the following is/are criterion/criteria for equilibrium of an isolated system held at constant temperature and constant pressure?

- (A) Entropy maximization
- (B) Entropy minimization
- (C) Maximization of Gibbs free energy
- (D) Minimization of Gibbs free energy

Q.30 Which of the following  $(h\ k\ l)$  reflections is/are allowed in an X-ray diffraction pattern of a crystal with face centered cubic lattice?

(A)  $(0\ 0\ 1)$

(B)  $(0\ 1\ 1)$

(C)  $(1\ 1\ 1)$

(D)  $(0\ 0\ 2)$

Q.31 The divergence of the vector field

$$\vec{V} = x^2y\hat{i} + y^3z\hat{j} + z^4\hat{k}$$

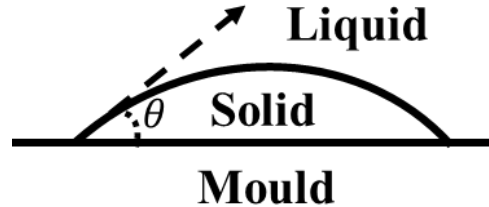
at the point  $(1,1,1)$  is \_\_\_\_\_. (Round off to the nearest integer)

Q.32 The pair-interaction energy between two atoms is given by the following expression:

$$U = -\frac{1.6}{r^6} + \frac{51.2}{r^{12}}$$

where  $U$  is the interaction energy in eV and  $r$  is the interatomic distance in Å.  
The equilibrium bond-length between the atoms is \_\_\_\_\_ Å.  
(Round off to the nearest integer)

- Q.33 For a solid embryo in contact with a perfectly flat mould wall as shown in the schematic, the wetting angle  $\theta$  is \_\_\_\_\_ degrees.  
(Round off to one decimal place).



Given:

Surface tension between liquid and mould wall =  $0.35 \text{ J} \cdot \text{m}^{-2}$

Surface tension between solid and mould wall =  $0.02 \text{ J} \cdot \text{m}^{-2}$

Surface tension between liquid and solid =  $0.40 \text{ J} \cdot \text{m}^{-2}$

- Q.34 A single crystal is oriented such that the normal to the slip plane makes an angle of  $60^\circ$  with the tensile axis. If the slip direction makes an angle of  $45^\circ$  with respect to the tensile axis and the critical resolved shear stress for slip is  $2 \text{ MPa}$ , then the tensile stress at which plastic deformation commences is \_\_\_\_\_  $\text{MPa}$ .  
(Round off to one decimal place)

- Q.35 The extrusion force required to extrude an aluminum rod of cross-sectional area of  $150 \text{ mm}^2$  to cross-sectional area of  $50 \text{ mm}^2$  is \_\_\_\_\_  $\text{N}$ .  
(Round off to the nearest integer)

Assume that the extrusion constant, which accounts for the flow stress, strain hardening, friction and inhomogeneous deformation, is equal to  $2 \text{ MPa}$ .

**Q.36 – Q.65 Carry TWO marks Each**

Q.36 If  $\begin{bmatrix} 1 & 2 \\ 8 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \lambda \begin{bmatrix} x \\ y \end{bmatrix}$ , where  $x, y$  are not identically zero, then the values of  $\lambda$  are

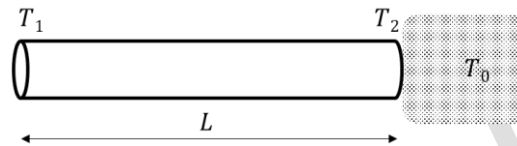
- (A)  $5, -3$
- (B)  $4, -4$
- (C)  $3, -5$
- (D)  $5, -4$

Q.37 If  $\frac{dy}{dx} = 4xy$ ,  $y(0) = 1$ , then

- (A)  $y = 2x^2 + 1$
- (B)  $y = 2e^{2x^2} - 1$
- (C)  $y = 2e^{x^2} - 1$
- (D)  $y = e^{2x^2}$



- Q.38 As shown in the figure, the right end of a slender, long solid cylindrical metal rod of thermal conductivity  $k$ , length  $L$  and diameter  $d$  ( $\ll L$ ) is in contact with an infinite liquid heat sink. At steady-state, the temperatures of the right end of the rod and the heat sink are  $T_2$  and  $T_0$ , respectively. If the convection heat transfer coefficient between the liquid heat sink and the right end of the rod is  $h$ , then what would be the temperature of the left end of the rod,  $T_1$ , at steady-state? Assume that there is no other heat loss.



- (A)  $T_1 = T_2 + (T_2 - T_0) \frac{hL}{k}$
- (B)  $T_1 = T_2 - (T_2 - T_0) \frac{hL}{k}$
- (C)  $T_1 = T_2 - (T_2 - T_0) \frac{k}{hL}$
- (D)  $T_1 = T_2 + (T_2 - T_0) \frac{k}{hL}$

Q.39 Match the dimensionless numbers listed in **Column I** with their applications to transport phenomena listed in **Column II**.

**Column I**

P. Reynolds number

Q. Schmidt number

R. Prandtl number

S. Biot number

**Column II**

1. Momentum and mass transfer

2. Momentum and heat transfer

3. Convective and conductive heat transfer

4. Laminar to turbulent flow

(A) P – 4, Q – 1, R – 3, S – 2

(B) P – 3, Q – 2, R – 4, S – 1

(C) P – 4, Q – 1, R – 2, S – 3

(D) P – 2, Q – 3, R – 1, S – 4

Q.40 In a cubic lattice, what is the ratio of interplanar spacings of the (100), (110) and (111) planes? (Round off to two decimal places)

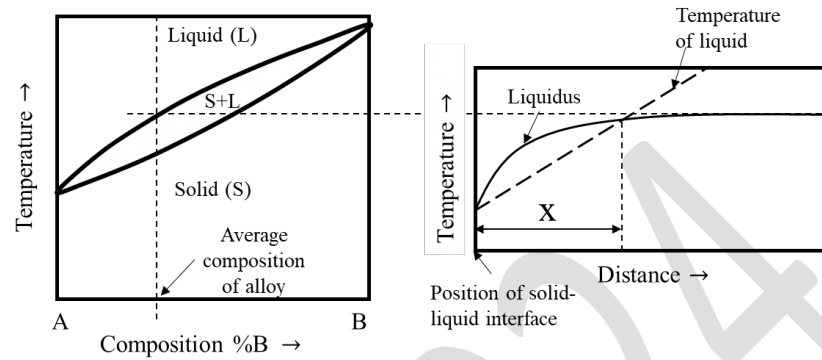
(A) 1 : 0.32 : 0.71

(B) 1 : 0.71 : 0.58

(C) 1 : 0.58 : 0.71

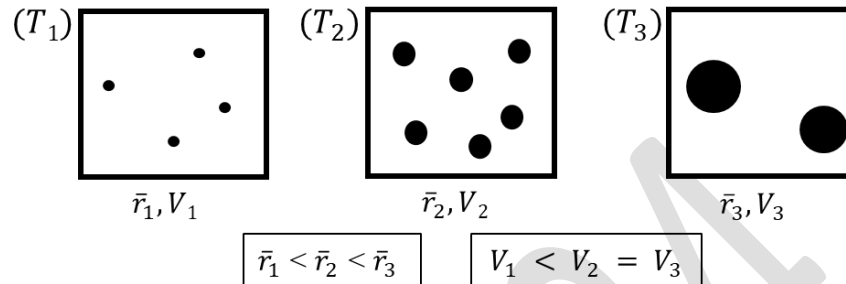
(D) 1 : 0.58 : 0.32

- Q.41 The constitutional undercooling condition for a hypothetical binary alloy of A with solute B during solidification is shown in the figure along with its binary phase diagram. Based on these two schematics, one can conclude that the solute concentration in region X will be \_\_\_\_\_ the average composition of the initial liquid phase.



- (A) less than
- (B) greater than
- (C) same as
- (D) independent of

- Q.42 The microstructures of a quenched steel tempered at three temperatures  $T_1 < T_2 < T_3$  for a fixed time are schematically illustrated. The solid circles represent cementite particles in ferrite matrix;  $\bar{r}_1$ ,  $\bar{r}_2$  and  $\bar{r}_3$  are average radii of cementite particles, and  $V_1$ ,  $V_2$  and  $V_3$  are volume fractions of cementite at temperatures  $T_1$ ,  $T_2$  and  $T_3$ , respectively.



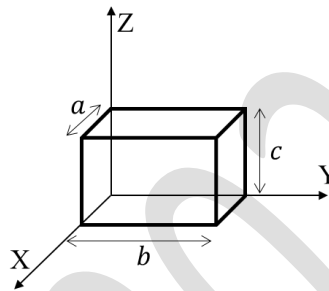
If the cementite in steel is more noble than ferrite, then which one of the three microstructures will have the highest corrosion rate when exposed to an aqueous solution of 3.5 wt. % NaCl?

- (A) Microstructure at  $T_1$
- (B) Microstructure at  $T_2$
- (C) Microstructure at  $T_3$
- (D) Independent of microstructure

Q.43

An isotropic metallic cuboid block shown in the figure has a coefficient of linear thermal expansion  $\alpha$ , Young's modulus  $E$  and Poisson's ratio  $\nu$ . The dimensions of the cuboid are  $a$ ,  $b$  and  $c$  in the X, Y and Z directions, respectively. It is rigidly constrained against expansion in the X direction. However, it is free to expand in the Y and Z directions. It is initially stress-free. Subsequently, it is heated so that its temperature increases by  $\Delta T$ . What would be the **CHANGE** in the dimension of the cuboid in the Y direction?

Assume linear elasticity, and that thermal as well as mechanical strains are infinitesimally small.



- (A)  $b(1 - \nu)\alpha\Delta T$
- (B)  $b(1 + \nu)\alpha\Delta T$
- (C)  $b\alpha\Delta T$
- (D)  $b(1 + \alpha)\Delta T$

Q.44 Match the entries in **Column I** with the stacking sequences of the close-packed planes listed in **Column II**.

**Column I**

P. Face centered cubic (FCC) structure

Q. Intrinsic stacking fault in FCC

R. Across an annealing twin boundary in FCC

S. Hexagonal close-packed structure

**Column II**

1. ABCABABC

2. ABABABAB

3. ABCABCABC

4. ABCABCACBACBA

(A) P – 1, Q – 3, R – 4, S – 2

(B) P – 2, Q – 3, R – 1, S – 4

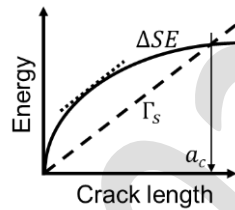
(C) P – 3, Q – 1, R – 4, S – 2

(D) P – 2, Q – 4, R – 1, S – 3

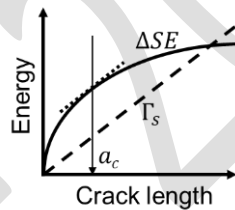
Q.45 Which one of the following graphs represents Griffith's criterion for the growth of a crack in a brittle isotropic infinitely large plate with a center crack?

In the graph,  $\Delta SE$  is the magnitude of the total strain energy released (shown by solid curve) and  $\Gamma_s$  is the total surface energy (shown by dashed line) and  $a_c$  is the critical crack length (shown by downward arrow) at which the crack starts growing. The tangent to the  $\Delta SE$  curve parallel to the  $\Gamma_s$  line is shown by the dotted line.

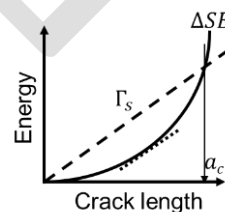
(A)



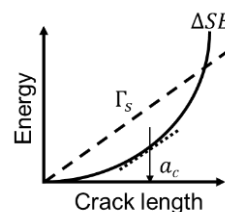
(B)



(C)



(D)



Q.46 For rolling of slabs, determine the correctness or otherwise of the following Assertion [a] and Reason [r].

Assertion [a]: Grooves are made on the surface of the rolls parallel to their roll axes to achieve large thickness reduction in a short time.

Reason [r]: Given  $\mu$  is the coefficient of friction between the rolls and the slab, and  $\alpha$  is the angle of bite between the entrance plane and the centerline of the rolls, unaided entry of slab in the rolls can take place only if  $\mu < \tan \alpha$ .

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

Q.47 Which of the following statements is/are correct?

- (A) Ultimate analysis of coal involves determination of moisture, volatile matter, fixed carbon and ash.
- (B) Reduction of wustite in blast furnace occurs at the lower part of the stack.
- (C) Roasting involves reduction of sulfide ores to pure metals.
- (D) White metal (impure  $\text{Cu}_2\text{S}$ ) is produced by oxidizing Fe and S during smelting of Cu-Fe matte.

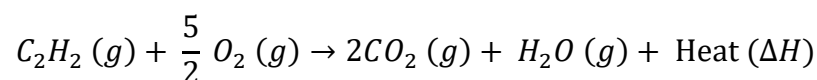


Q.48 A creep test of a pure polycrystalline metal is performed in tension and the creep strain rate is observed to decrease during the primary stage. The creep mechanism is later determined to be dislocation-climb-controlled. The observed decrease in creep strain rate is/are due to

- (A) an increase in dislocation density.
- (B) grain growth.
- (C) a decrease in the dislocation density.
- (D) an increase in the cross-sectional area of the sample.

Q.49 Which of the following statements is/are correct for joining processes?

- (A) In case of soldering and brazing, the filler material has a melting point lower than that of the metals joined.
- (B) In tungsten inert gas welding, tungsten is the filler material.
- (C) Friction welding is a solid-state joining process.
- (D) The following reaction is associated with thermit welding:



Note: (g) stands for gas.

Q.50 Which of the following statements is/are correct for non-destructive testing?

- (A) Liquid dye penetration technique can be utilized for detecting surface cracks.
- (B) In radiographic examination, internal cracks cannot be detected.
- (C) Eddy current-based techniques can be used for detecting sub-surface defects in pure alumina at room temperature.
- (D) Ultrasonic inspection is unsuitable for inspecting sub-surface defects in high damping capacity material (e.g., cast iron).

Q.51 The following data is obtained from an experiment:

$x$	1	2	3
$y$	8	15	19

If the data is fit using the straight line

$$y = mx + c \text{ (where } m \text{ and } c \text{ are constants)}$$

using the least-squares method, then the value of  $m$  is \_\_\_\_\_.  
(Round off to one decimal place).

Q.52 The integral  $\int_0^1 xe^{-x} dx$  evaluates to \_\_\_\_\_.  
(Round off to two decimal places)

- Q.53 If for element A, the formation enthalpy and formation entropy per vacancy created are  $0.5 \text{ eV}$  and  $3k_B$ , respectively, then the equilibrium vacancy concentration (in mole fraction) at  $500 \text{ K}$  is \_\_\_\_\_  $\times 10^{-4}$ .  
(Round off to two decimal places)

Given: Boltzmann constant,  $k_B = 8.62 \times 10^{-5} \text{ eV} \cdot \text{atom}^{-1} \cdot \text{K}^{-1}$

- Q.54 A steel bar is subjected to fatigue loading with a tensile mean stress. Given that the ultimate tensile strength is  $1000 \text{ MPa}$  and the fatigue limit under fully reversed loading is  $250 \text{ MPa}$ , the fatigue limit for a mean stress of  $100 \text{ MPa}$ , considering Goodman relationship is \_\_\_\_\_  $\text{MPa}$ .  
(Round off to the nearest integer)

- Q.55 During carburization of a steel at  $950^\circ \text{C}$ , carbon concentration is measured as  $0.8 \text{ wt.}\%$  at a depth of  $0.3 \text{ mm}$  after one hour. The time required to get the same carbon concentration at a depth of  $0.6 \text{ mm}$  at the same carburization temperature is \_\_\_\_\_ hours. (Round off to the nearest integer).

- Q.56 An ideal solution is formed by mixing  $10 \text{ grams}$  of A and  $50 \text{ grams}$  of B at  $673 \text{ K}$ . The molar free energy of mixing \_\_\_\_\_  $\text{kJ} \cdot \text{mol}^{-1}$ .  
(Round off to one decimal place)

Given: Universal gas constant  $R = 8.314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$

Atomic weight of A =  $40 \text{ grams} \cdot \text{mol}^{-1}$

Atomic weight of B =  $60 \text{ grams} \cdot \text{mol}^{-1}$

- Q.57 The cupric ion ( $\text{Cu}^{2+}$ ) concentration in the electrolyte (at 298 K) required to make the potential of pure copper equal to 0.17 V is \_\_\_\_\_  $\times 10^{-6} \text{ gram-mol. (litre)}^{-1}$ .  
(Round off to two decimal places).

Gas constant  $R = 8.314 \text{ J.mol}^{-1}.\text{K}^{-1}$

Faraday's constant  $F = 96500 \text{ C.mol}^{-1} \text{ (of electrons)}$

Standard reduction potential of Cu,  $E^0 = 0.34 \text{ V}$

- Q.58 A non-porous spherical  $\text{Fe}_2\text{O}_3$  particle of initial radius of  $5 \times 10^{-2} \text{ m}$  is topo-chemically reduced by  $\text{H}_2$ , where the reactant-product interface is sharp and spherical, and reaction rate is proportional to the interfacial area. The radius of the unreacted  $\text{Fe}_2\text{O}_3$  particle after 600 s will be \_\_\_\_\_  $\times 10^{-2} \text{ m}$ .  
(Round off to the nearest integer).

Given: Rate constant  $k = 5 \times 10^{-5} \text{ m.s}^{-1}$

- Q.59 A long metallic cylindrical rod of radius  $r$ , length  $L$  ( $\gg r$ ) and electrical resistivity  $\rho_e$  is kept in vacuum and is carrying an electric current of  $I$ . The only way it loses heat to the ambient is via radiation. If the ambient temperature is  $T_0$ , then the steady-state temperature of the rod is \_\_\_\_\_ K.  
(Round off to the nearest integer).

Given: Stefan-Boltzmann constant =  $5.667 \times 10^{-8} \text{ W.m}^{-2}.\text{K}^{-4}$

$r = 0.1 \text{ mm}$        $L = 1 \text{ m}$        $\rho_e = 10^{-8} \Omega.\text{m}$

$I = 0.3 \text{ A}$        $T_0 = 300 \text{ K}$

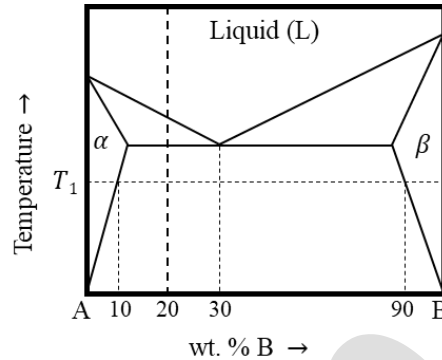
Neglect the heat loss by the two flat ends of the rod and assume emissivity = 1.

- Q.60 1000 kg of sphalerite concentrate containing 60% ZnS is **COMPLETELY** roasted with stoichiometric amount of pure oxygen. The amount of oxygen required is \_\_\_\_\_ kg. (Round off to one decimal place).

Assume that the other components in the concentrate are not reactive.

Given: Atomic weight values (in  $\text{gram.mol}^{-1}$ ) for Zn = 65, S = 32, O = 16.

- Q.61 800 *grams* of A-B alloy containing 20 wt.% B is held at temperature  $T_1$ . The weight of B dissolved in  $\alpha$  at that temperature is \_\_\_\_\_ *grams*. (Round off to the nearest integer).



- Q.62 A mild steel pipeline is connected to zinc for cathodic protection at a current density of  $10 \text{ mA} \cdot \text{m}^{-2}$ . The quantity of zinc required per square meter of the pipeline per year is \_\_\_\_\_ *grams*. (Round off to the nearest integer).

Given: Atomic weight of Zn is  $65 \text{ gram} \cdot \text{mol}^{-1}$ .

Faraday's constant  $F = 96500 \text{ C} \cdot \text{mol}^{-1}$  (of electrons)

- Q.63 A large rectangular component is undergoing fully-reversed cyclic loading, and the component is known to grow the dominant fatigue crack from the outer surface. If the stress amplitude ( $\sigma_A$ ) is  $100 \text{ MPa}$  and the critical stress intensity factor  $K_{IC}$  of the material is  $50 \text{ MPa} \cdot \text{m}^{\frac{1}{2}}$  then the crack length at which the component will fail catastrophically is \_\_\_\_\_ *mm*. (Round off to one decimal place)

Given: The geometric factor  $\alpha$  for this loading condition is 1.12.

- Q.64 In casting, for a simple vertical gating system with a gate of cross-sectional area  $2 \text{ cm}^2$  and spruce height of  $10 \text{ cm}$ , the filling time for a mould of dimensions  $40 \text{ cm} \times 20 \text{ cm} \times 10 \text{ cm}$ , is \_\_\_\_\_ *s*. (Round off to one decimal place)

Given: Acceleration due to gravity  $g = 980 \text{ cm} \cdot \text{s}^{-2}$

- Q.65 During arc welding, the actual heat input is  $200 \text{ J. mm}^{-3}$  and the current and voltage are  $200 \text{ A}$  and  $20 \text{ V}$ , respectively. For a weld cross-sectional area of  $2 \text{ mm}^2$  and heat transfer efficiency of  $0.9$ , the velocity of welding is \_\_\_\_\_  $\text{mm. s}^{-1}$ . (Round off to the nearest integer).

GATE 2024