GENERAL APTITUDE

Q. No. 1-5 Carry One Mark Each

1. If ‘ $\rightarrow$; denotes increasing order of intensity, then the meaning of the words [dry $\rightarrow$ arid $\rightarrow$ parched] is analogous to [diet $\rightarrow$ fast $\rightarrow$ ________].

Which one of the given options is appropriate to fill the blank?

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

Key: (A)

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

Key: (D)

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

Key: (A)

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%

Key: (C)

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

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

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

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

Key: (A)

Q. No. 6-10 Carry Two Marks Each

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

Key: (C)

7. A rectangular paper sheet of dimensions 54 cm × 4 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.

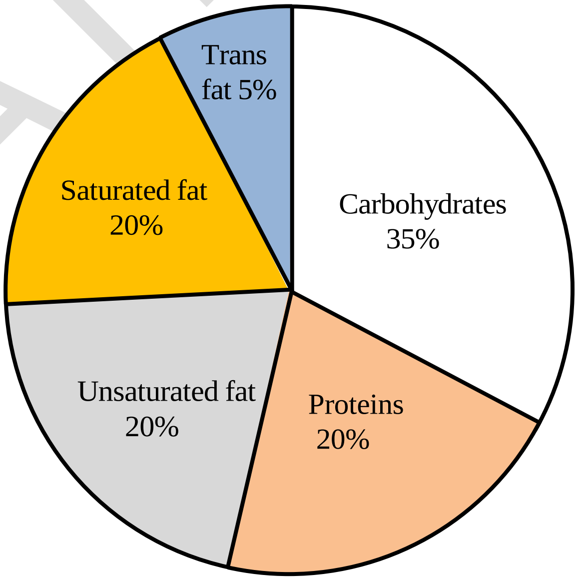
Then, the ratio of the volume of the cylindrical tube to the volume of the cube is

(A) $\frac{1}{\pi}$ (B) $\frac{2}{\pi}$ (C) $\frac{3}{\pi}$ (D) $\frac{4}{\pi}$

Key: (A)

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

Macronutrient energy contribution



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) 3600

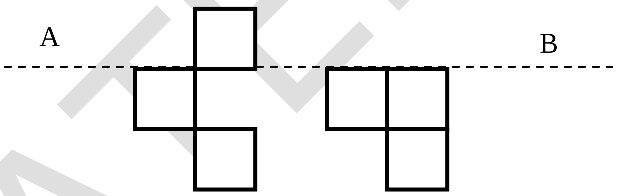
Key: (C)

9. A rectangular paper of 20 cm × 8 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

Key: (A)

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

Key: (A)

METTALLURGICAL ENGINEERING

Q. No. 11-35 Carry One Mark Each

11. If X_1 and X_2 are independent normally distributed random variables with means μ_1 and μ_2, and variances ρ_1 and ρ_2, respectively, then the combination $X = X_1 + X_2$ has mean μ and variance ρ 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 $\rho^2 = \rho_1^2 + \rho_2^2$

Key: (A)

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

(A) $x - \frac{x^2}{2} + \frac{x^3}{3} - ...$

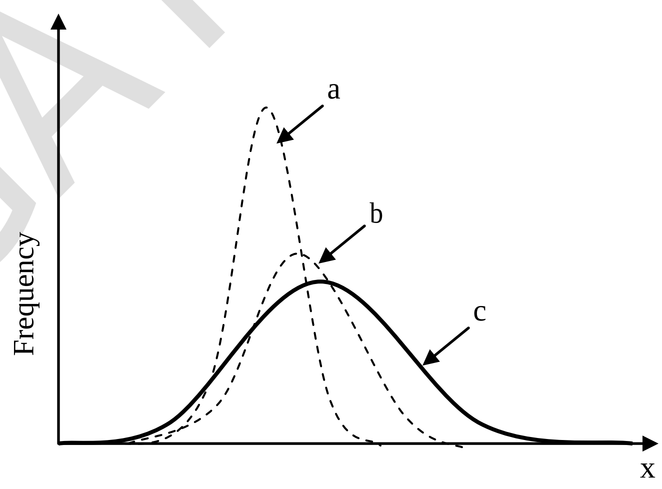
(B) $2\left(x - \frac{x^2}{2} + \frac{x^3}{3} - ...\right)$

(C) $x + \frac{x^3}{3} + \frac{x^5}{5} + ...$

(D) $2\left(x + \frac{x^3}{3} + \frac{x^5}{5} + ...\right)$

Key: (D)

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



σ_p and μ_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) $\mu_a > \mu_b > \mu_c$

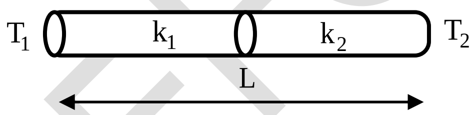
Key: (A)

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) $a_A X_A^2$

Key: (A)

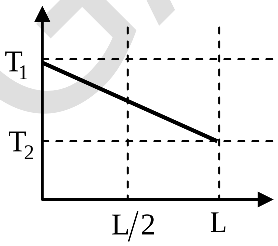
15. As shown in the figure, two rods of different metals of equal lengths, $\frac{L}{2}$, diameter d (d << L), and constant thermal conductivities k_1 and k_2 (with $k_1 > k_2$) are connected perfectly (i.e.., zero interface thermal resistance).



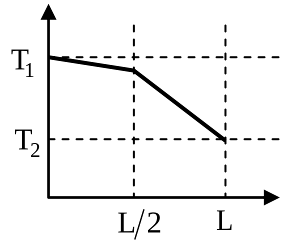
The left and right ends of the connected rod are maintained at temperatures T_1 and $T_2 (T_1 > T_2)$. Assume that the rods are insulated from the environment, apart from the two flat ends.

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 distances from the left end of the rod to the right and the vertical axis denotes temperature.

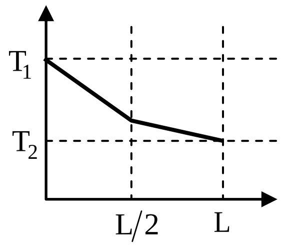
(A)



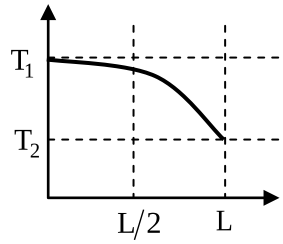
(B)



(C)



(D)



Key: (B)

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

Column I		Column II	
(P)	Hooke's law	(1)	Thermal conductivity
(Q)	Fick's law	(2)	Young's modulus
(R)	Fourier's law	(3)	Permeability
(S)	Darcy's law	(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

Key: (C)

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

(A) fine (< 75 μm) paramagnetic minerals
(B) coarse (> 75 μm) ferromagnetic minerals.
(C) coarse (> 75 μm) paramagnetic minerals.
(D) fine (< 75 μm) ferromagnetic minerals.

Key: (A)

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

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

Key: (A)

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

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

(A) $C(s)+H_2O(\ell)\rightarrow H_2(g)+CO(g)$

(B) $C(s)+O_2(g)\rightarrow CO_2(g)$

(C) $C(s)+CO_2(g)\rightarrow 2CO(g)$

(D) $2C(s)+O_2(g)\rightarrow 2CO(g)$

Key: (C)

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

Key: (A)

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.

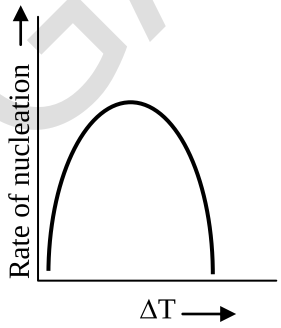
(C) Cell is operated at a high voltage (220 to 240 V) with a very high current density.

(D) Cell is operated at a low voltage (5 to 7 V) with a very high current density.

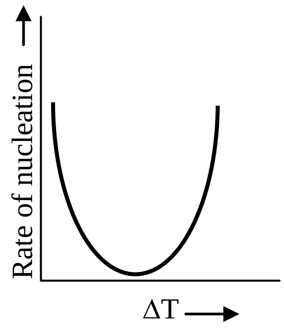
Key: (D)

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)?

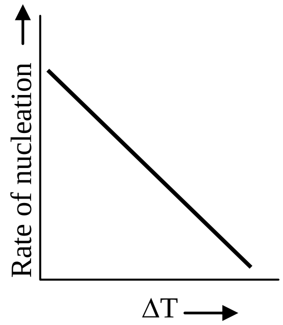
(A)



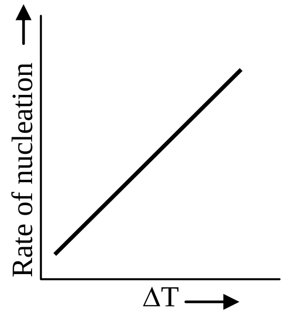
(B)



(C)



(D)



Key: (A)

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

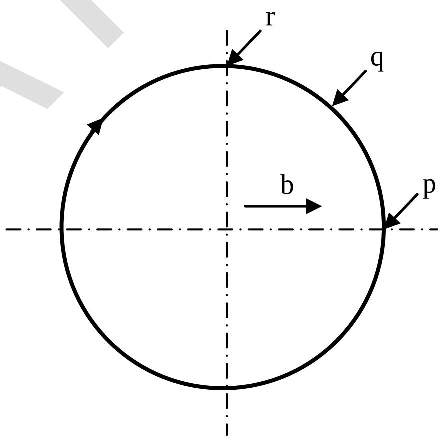
(B) Face centered cubic to body centered tetragonal

(C) Body centered cubic to body centered tetragonal

(D) Body centered tetragonal to face centered cubic

Key: (MTA)

24. The figure shows a dislocation loop (shown by the solid circle), whose Burgers vector is **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

Key: (A)

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

Column I	Column II
P. Peierls-Nabarro stress	**1.** Yield point phenomenon
Q. Cottrell's atmosphere	**2.** Fatigue
R. Paris law	**3.** Dislocation glide
S. Considère's criterion	**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

Key: (C)

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

Column I	Column II
P. Misrun	1. Extrusion
Q. Earing	2. Rolling
R. Alligatoring	3. Casting
S. Chevron cracking	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

Key: (B)

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

Key: (B)

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

Key: (B, C)

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

Key: (A, D)

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)

Key: (C, D)

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)

Key: (9)

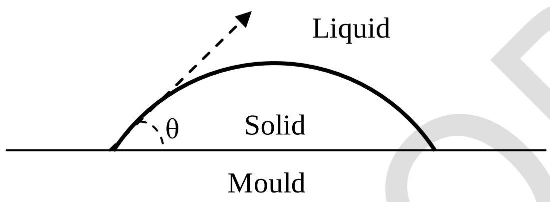
32. The pair-interaction energy between two atoms is given by the following expression:

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

Where U is the interaction energy in eV and r is the interatomic distance in $\overset{o}{A}$. The equilibrium bond-length between the atoms is _______________ $\overset{o}{A}$. (Round off to the nearest integer).

Key: **(2)**

33. For a solid embryo in contact with a perfectly flat mould wall as shown in the schematic, the wetting angle θ is________ degrees. (Round off to one decimal place).



Given:

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

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

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

Key: **(33.0 to 35.0)**

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

Key: **(5.5 to 5.8)**

35. The extrusion force required to extrude and aluminum rod of cross-sectional area of 150 mm^2 to cross-sectional area of 50 mm^2 is __________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 MPa.

Key: (328 to 331)

Q. No. 36-65 Carry Two Marks Each

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 λ are

(A) 5, –3 (B) 4, –4 (C) 3, –5 (D) 5, –4

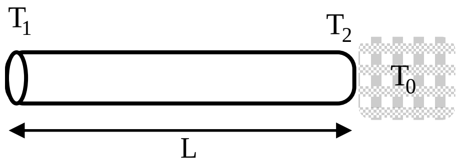
Key: (A)

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) $y = e^{2x^2}$

Key: (D)

38. As shown in the figure, the right end of the a slender, long solid cylindrical metal rod of thermal conductivity k, length L and diameter d (<< 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) $T_1 = T_2 + (T_2 - T_0)\frac{k}{hL}$

Key: (A)

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

Column I	Column II
P. Reynolds number	1. Momentum and mass transfer
Q. Schmidt number	2. Momentum and heat transfer
R. Prandtl number	3. Convective and conductive heat transfer
S. Biot number	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

Key: (C)

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

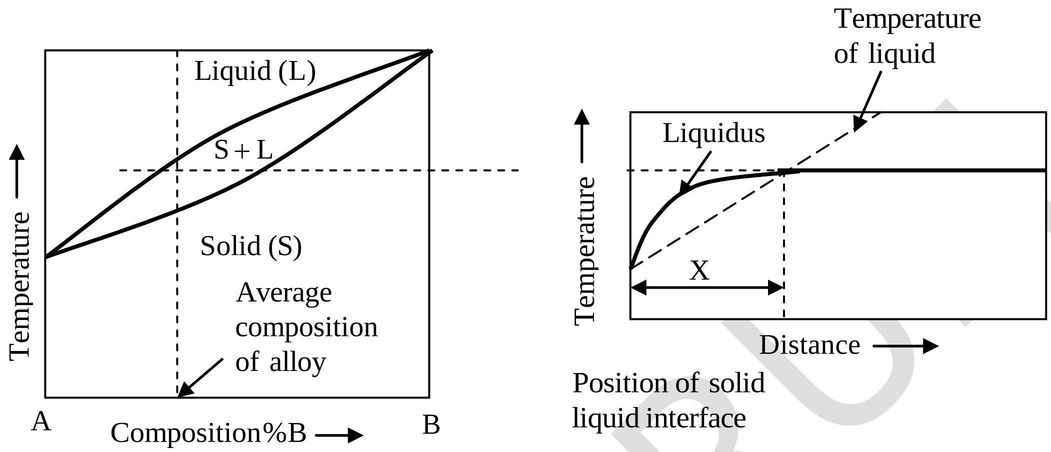
(B) 1 : 0.71 : 0.58

(C) 1 : 0.58 : 0.71

(D) 1 : 0.58 : 0.32

Key: (B)

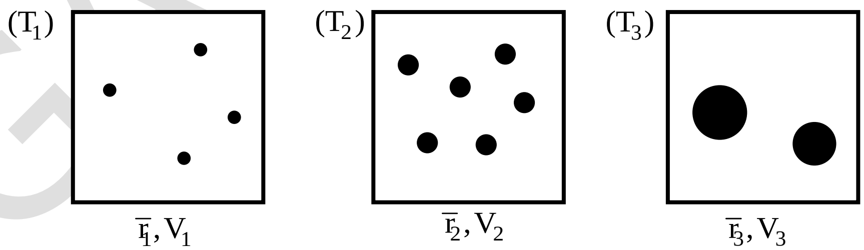
41. The constitutional undercooling condition for a hypothetical binary alloy of A with solute B during solidification is shown in the figure along with its binary phase diagram. Based on these two schematics, one can conclude that the solute concentration in region X will be ____________ the average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



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

Key: (A)

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.



$\bar{r}_1 < \bar{r}_2 < \bar{r}_3$ $\quad$ $V_1 < V_2 = V_3$

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?

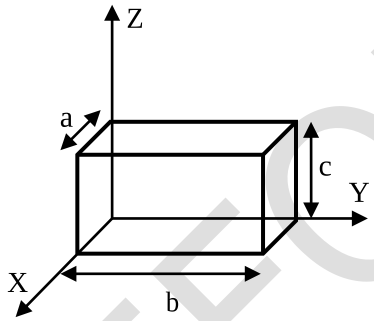
(A) Microstructure at T_1 (B) Microstructure at T_2

(C) Microstructure at T_3 (D) Independent of microstructure

Key: (B)

43. An isotropic metallic cuboid block shown in the figure has a coefficient of linear thermal expansion α, Young's modulus E and Poisson's ratio ν. 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 ΔT. 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) $b(1-v)\alpha\Delta T$ (B) $b(1+v)\alpha\Delta T$ (C) $b\alpha\Delta T$ (D) $b(1+\alpha)\Delta T$

Key: (B)

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

Column I	Column II
P. Face centered cubic (FCC) structure	1. ABCABABC
Q. Intrinsic stacking fault in FCC	2. ABABABAB
R. Across an annealing twin boundary in FCC	3. ABCABCABC
S. Hexagonal close-packed structure	4. ABCABCACBACBA

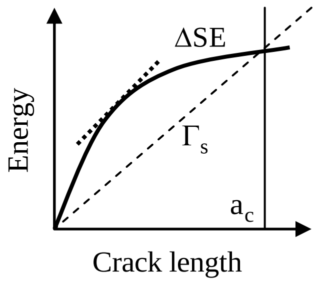
(A) P – 1, Q – 3, R – 4, S – 2 (B) P – 2, Q – 3, R – 1, S – 4

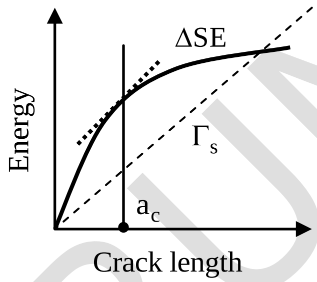
(C) P – 3, Q – 1, R – 4, S – 2 (D) P – 2, Q – 4, R – 1, S – 3

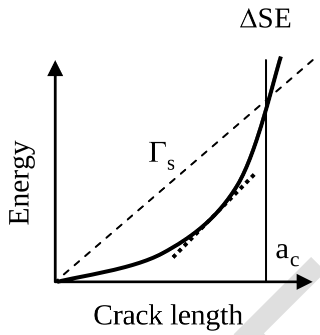
Key: (C)

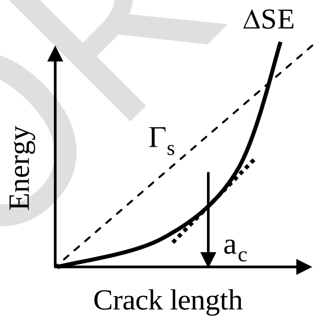
45. Which one of the following graphs represents Griffith's criterion for the growth of a crack in a brittle isotropic infinitely large plate with a center crack?

In the graph, ΔSE is the magnitude of the total strain energy released (shown by solid curve) and Γ_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 ΔSE curve parallel to the Γ_s line is shown by the dotted line.

(A)


(B)


(C)


(D)


Key: (D)

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 μ is the coefficient of friction between the rolls and the slab, and α 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.

Key: (D)

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 $(\text{impure } Cu_2S)$ is produced by oxidizing Fe and S during smelting of Cu-Fe matte.

Key: (B, D)

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.

Key: (A)

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:

$$C_2H_2(g) + \frac{5}{2}O_2(g) \rightarrow 2CO_2(g) + H_2O(g) + \text{Heat}(\Delta H)$$

Note: (g) stands for gas.

Key: (A. C)

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).

Key: (A, D)

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

$y = mx + c$ (where m and c are constants)

using the least-squares method, then the value of m is _________.

(Round off to one decimal place).

Key: (5.2 to 5.8)

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

Key: (0.24 to 0.28)

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

Given: Boltzmann constant, $k_B = 8.62\times10^{-5}$ eV.atom^{-1}.K^{-1}.

Key: (1.7 to 2.0)

54. A steel bar is subjected to fatigue loading with a tensile mean stress. Given that the ultimate tensile strength is 1000 MPa and the fatigue limit under fully reversed loading is 250 MPa, the fatigue limit for a mean stress of 100 MPa, considering Goodman relationship is ______ MPa.

(Round off to the nearest integer)

Key: (225 to 225)

55. During carburization of a steel at 950℃, carbon concentration is measured as 0.8 wt.% at a depth of 0.3 mm after one hour. The time required to get the same carbon concentration at a depth of 0.6 mm at the same carburization temperature is _____ $hours$. (Round off to the nearest integer).

Key: (4)

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

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

Atomic weight of A = 40 grams. mol^{-1}

Atomic weight of B = 60 grams. mol^{-1}

Key: (-3.2 to –2.8)

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

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

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

Standard reduction potential of Cu, $E^{o} = 0.34V$

Key: (1.6 to 1.9)

58. A non-porous spherical Fe_2O_3 particle of initial radius of $5\times10^{-2}\,m$ is topo-chemically reduced by 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 Fe_2O_3 particle after 600 s will be __________ $\times10^{-2}\,m$. (Round off to the nearest integer).

Given: Rate constant $k = 5\times10^{-5}\,m.s^{-1}$

Key: (2)

59. A long metallic cylindrical rod of radius r, length L (>>r) and electrical resistivity ρ_e is kept in vacuum and is carrying an electric current of I. The only way it losses 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 $= 5.667\times10^{-8}\,W.m^{-2}.K^{-4}$

$r = 0.1\,mm$ $\quad L = 1\,m$ $\quad \rho_e = 10^{-8}\,\Omega.m$
$I = 0.3A$ $\quad T_0 = 300\,K$

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

Key: (305 to 308)

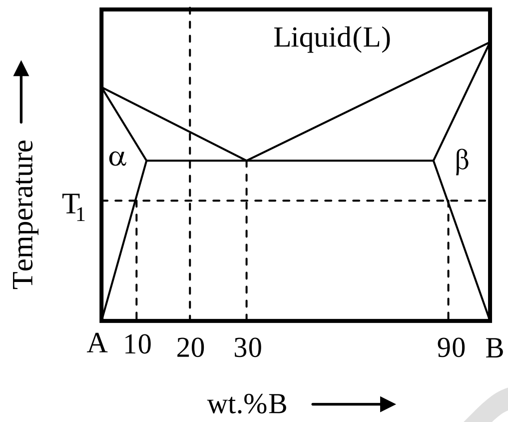
60. 1000 kg of sphalerite concentrate containing 60% ZnS is COMPLETELY roasted with stoichiometric amount of pure oxygen. The amount of oxygen required is _________ kg (Round off to one decimal place).

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

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

Key: (295.0 to 300.0)

61. 800 grams of A-B alloy containing 20 wt% B is held at temperature T_1. The weight of B dissolved in α at that temperature is ________ grams. (Round off to the nearest integer).



Key: (70)

62. A mild steel pipeline is connected to zinc for cathodic protection at a current density of 10 $mA.m^{-2}$. 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 $gam.mol^{-1}$.

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

Key: (105 to 107)

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 (σ_A) is 100 MPa and the critical stress intensity factor K_{1C} of the material is 50 MPa. $m^{\frac{1}{2}}$ then the crack length at which the component will fail catastrophically is _______mm.

(Round off to one decimal place)

Given: The geometric factor α for this loading condition is 1.12.

Key: (62.5 to 64.5)

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

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

Key: (27.0 to 30.0)

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

Key: (9)

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