GENERAL APTITUDE

Q. No. 1 - 5 Carry One Mark Each

1. Five persons P, Q, R, S and T are to be seated in a row, all facing the same direction, but not necessarily in the same order. P and T cannot be seated at either end of the row. P should not be seated adjacent to S. R is to be seated at the second position from the left end of the row. The number of distinct seating arrangements possible is:

(A) 2 (B) 3 (C) 4 (D) 5

Answer: (B)

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2. Consider the following sentences:

(i) The number of candidates who appear for the GATE examination is staggering.

(ii) A number of candidates from my class are appearing for the GATE examination.

(iii) The number of candidates who appear for the GATE examination are staggering.

(iv) A number of candidates from my class is appearing for the GATE examination.

Which of the above sentences are grammatically CORRECT?

(A) (i) and (ii) (B) (i) and (iii)

(C) (ii) and (iii) (D) (ii) and (iv)

Answer: (A)

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3. A digital watch X beeps every 30 seconds while watch Y beeps every 32 seconds. They beeped together at 10 AM.

The immediate next time that they will beep together is

(A) 10.08 AM (B) 10.42AM (C) 11.00 AM (D) 10.00PM

Answer: (A)

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4. If $\oplus \div \odot = 2; \oplus \div \Delta = 3; \odot + \Delta = 5; \Delta \times \otimes = 10,$

Then, the value of $(\otimes - \oplus)^2$, is

(A) 0 (B) 1 (C) 4 (D) 16

Answer: (B)

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5. The front door of Mr. X's house faces East. Mr. X leaves the house, walking 50m straight from the back door that is situated directly opposite to the front door. He then turns to his right, walks for another 50 m and stops. The direction of the point Mr. X is now located at with respect to the starting point is _____

(A) South-East (B) North-East

(C) West (D) North-West

Answer: (D)

Q. No. 6 to 10 Carry Two Marks Each

6. Given below are two statements 1 and 2, and two conclusions I and II.

Statement 1: All entrepreneurs are wealthy.

Statement 2: All wealthy are risk seekers.

Conclusion I: All risk seekers are wealthy.

Conclusion II: Only some entrepreneurs are risk seekers.

Based on the above statements and conclusions, which one of the following options is CORRECT?

(A) Only conclusion I is correct

(B) Only conclusion II is correct

(C) Neither conclusion I nor II is correct

(D) Both conclusions I and II are correct

Answer: (C)

7. A box contains 15 blue balls and 45 black balls. If 2 balls are selected randomly, without replacement, the probability of an outcome in which the first selected is a blue ball and the second selected is a black ball, is

(A) $\frac{3}{16}$ (B) $\frac{45}{236}$ (C) $\frac{1}{4}$ (D) $\frac{3}{4}$

Answer: (B)

8.

The ratio of the area of the inscribed circle to the area of the circumscribed circle of an equilateral triangle is

(A) $\frac{1}{8}$ (B) $\frac{1}{6}$ (C) $\frac{1}{4}$ (D) $\frac{1}{2}$

Answer: (C)

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9. Consider a square sheet of side 1 unit. The sheet is first folded along the main diagonal. This is followed by a fold along its line of symmetry. The resulting folded shape is again folded along its line of symmetry. The area of each face of the final folded shape, in square units, equal to _____

(A) $\frac{1}{4}$ (B) $\frac{1}{8}$ (C) $\frac{1}{16}$ (D) $\frac{1}{32}$

Answer: (B)

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10. The world is going through the worst pandemic in the past hundred years. The air travel industry is facing a crisis, as the resulting quarantine requirement for travelers led to weak demand.

In relation to the first sentence above, what does the second sentence do?

(A) Restates an idea from the first sentence.

(B) Second sentence entirely contradicts the first sentence.

(C) The two statements are unrelated.

(D) States an effect of the first sentence.

Answer: (D)

Metallurgical Engineering

Q. No. 1-25 Carry One Mark Each

1. For the matrix given below, the eigen values are:

$$\begin{pmatrix} 1 & 0 & -1 \\ 0 & 1 & 0 \\ -1 & 0 & 1 \end{pmatrix}$$

(A) 0, 2, 2 (B) 1, 1, 2 (C) 0, 1, 2 (D) 0, 1, 3

Answer: (C)

---

2. Which one of the following is a homogeneous function of degree three?

(A) $x^3 + 2x^2y^2$ (B) $y^2x + 2yx^2$

(C) $y^3 + 2x^2$ (D) $xy^2 + 3xy$

Answer: (B)

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3. The divergence of a vector field $\vec{V}(x, y, z)$, where its three components (V_x, V_y, V_z) are functions of x, y, z, is:

(A) $\frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} + \frac{\partial V_z}{\partial z}$

(B) $\left(\frac{\partial V_z}{\partial y} - \frac{\partial V_y}{\partial z}\right)i + \left(\frac{\partial V_x}{\partial z} - \frac{\partial V_z}{\partial x}\right)j + \left(\frac{\partial V_y}{\partial x} - \frac{\partial V_x}{\partial y}\right)k$

(C) $\frac{\partial V_x}{\partial x}i + \frac{\partial V_y}{\partial y}j + \frac{\partial V_z}{\partial z}k$

(D) $\frac{\partial^2 V_x}{\partial x^2} + \frac{\partial^2 V_y}{\partial y^2} + \frac{\partial^2 V_z}{\partial z^2}$

Answer: (D)

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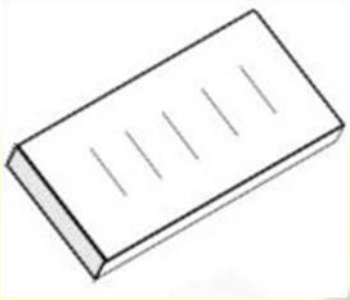
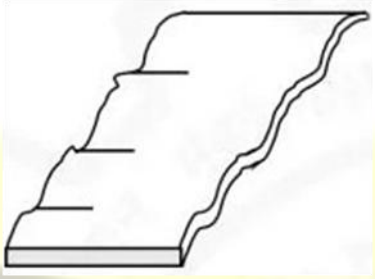
4. Which one of the following is 'center split' defect in rolling operation?

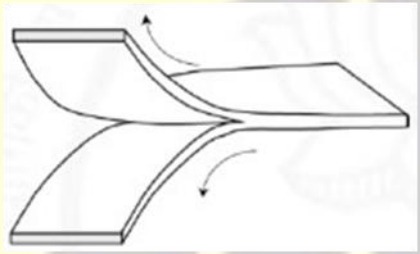
(A)



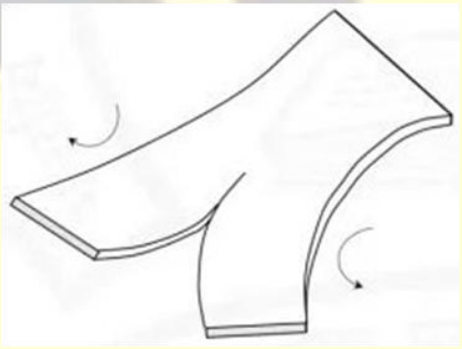
(B)



(C)



(D)



Answer: (D)

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5. Single crystal turbine blades of nickel-based superalloys for aero-engines are manufactured using:

(A) Investment casting

(B) Die casting

(C) Squeeze casting

(D) Directional solidification

Answer: (D)

---

6. Elements A and B have the same crystal structure. For a dilute solution of B in A, which one of the following is true?

(Given: ΔH_{mix} – Mixing enthalpy, a_B – Activity of B and X_B – Mole fraction of B)

(A) If $\Delta H_{mix} = 0$, then $a_B < X_B$

(B) If $\Delta H_{mix} = 0$, then $a_B > X_B$

(C) If $\Delta H_{mix} > 0$, then $a_B < X_B$

(D) If $\Delta H_{mix} < 0$, then $a_B < X_B$

Answer: (D)

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7. For uniaxial tensile stress-strain behaviour of polycrystalline aluminium, which one of the following statements is FALSE?

(A) True stress is always higher than the engineering stress.

(B) At the ultimate tensile stress point on the true stress - strain curve, $\frac{d\sigma}{a\varepsilon} = 0$

(C) Resilience is the area under the elastic region of the engineering stress - strain curve.

(D) Maximum true stress does not correspond to the maximum load.

Answer: (B)

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8. Which one of the following is FALSE for creep deformation?

(A) The minimum creep rate is obtained in the primary stage (stage I).

(B) Creep resistance decreases with decrease in grain size.

(C) Coble creep occurs via grain boundary diffusion.

(D) Nabarro-Herring creep occurs via lattice diffusion.

Answer: (A)

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9. Which one of the following elements alloyed with iron is a ferrite stabilizer?

(A) Nickel (B) Manganese (C) Carbon (D) Silicon

Answer: (D)

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10. Which one of the following is the correct decreasing sequence of Quenching Power for quenchants used in heat treatment of steels?

(A) Oil > Water> Brine> Air (B) Brine > Oil > Water > Air

(C) Brine > Water > Oil > Air (D) Water> Brine> Oil> Air

Answer: (C)

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11. For a zeroth order chemical reaction, which one of the following is FALSE?

(A) Concentration versus time plot is a straight line.

(B) Increase in concentration of reacting species increases the rate of reaction.

(C) Half-life depends on the initial concentration and zero-order rate constant.

(D) Rate of reaction depends on temperature.

Answer: (B)

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12. Which one of the following elements oxidizes first in basic oxygen steel making process?

(A) Silicon (B) Carbon (C) Manganese (D) Phosphorns

Answer: (A)

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13. Which one of the following is a hydrometallurgical operation?

(A) Roasting (B) Leaching (C) Zone refining (D) Smelting

Answer: (B)

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14. The value of $\lim_{x\to 0}\frac{\sin^2 5x}{\sin^2 x}$ is: _____ (round off to nearest integer).

Answer: (25 to 25)

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15. The grain size (X) of annealed specimens follows a symmetric distribution with a mean(μ) of 5 um and a standard deviation (a) of 0.5 μm. The percentage of specimens with grain size in the range 5 to 6 μm is expected to be: (round off to nearest integer).

Given: For the symmetric distribution: Probability $P\left(X \le \mu + 2\sigma\right) = 0.98$

Answer: (48 to 48)

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16. If $E^{o}_{Ni^{2+}/Ni} = -0.25\,V$, the value of $\mu^{o}_{Ni^{2+}}\left(\text{in J mol}^{-1}\right)$ at 298 K is: _____ (round off to nearest integer).

Given: F = 96500 C mol^{-1}

Answer: (–48251 to –48240)

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17. Melting point of Cu is 1358 K and its enthalpy of melting is 13400 J mol^{-1}. The value of free energy change (in J mol') for liquid to solid transformation at 1058 K is: (round off to nearest integer).

Assume: $C_P^{liquid} = C_P^{solid}$

Answer: (–2962 to –2958)

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18. A body is subjected to a state of stress given by the following stress tensor:

$$\begin{pmatrix} 50 & 0 & 0 \\ 0 & 200 & 0 \\ 0 & 0 & 100 \end{pmatrix} \text{MPa.}$$

If yielding is predicted by the Tresca Criterion, the uniaxial tensile yield stress (in MPa) of the body should be less than or equal to: _____ (round off to nearest integer).

Answer: (150 to 150)

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19. Consider homogeneous nucleation of a spherical solid in liquid. For a given undercooling, if surface energy of a nucleus increases by 20 %, the corresponding increase (in percent) in the critical radius of the nucleus is: _____(round off to nearest integer).

Answer: (20 to 20)

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20. If saturation magnetization of iron at room temperature is $1700\ \text{kA m}^{-1}$, the magnetic moment $\left(\text{in A m}^2\right)$ per iron atom in the crystal is: _____ $\times 10^{-23}$ (round off to 1 decimal place).

(Given: Lattice parameter of iron at room temperature = 0.287 nm)

Answer: (1.7 to 2.3)

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21. In the X-ray diffraction pattern of a FCC crystal, the first reflection occurs at a Bragg angle (θ) of 30°. The Bragg angle (in degree) for the second reflection will be:_____ (round off to 1 decimal place).

Answer: (34.8 to 36.1)

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22. A 0.6 wt.% C steel sample is slowly cooled from 900 °C to room temperature. The fraction of proeutectoid ferrite in the microstructure is: _____ (round off to 2 decimal places).

Given: Eutectoid composition: 0.8 wt.% C

Maximum solubility of carbon in α-Fe : 0.025 wt.%C

Answer: (0.22 to 0.30)

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23. If the degree of polymerization of polyethylene is 30000, the average molecular weight (in g mol^{-1}) is:_____(round off to nearest integer).

(Given: Atomic weights of carbon and hydrogen are 12 and 1, respectively)

Answer: (840000 to 840000)

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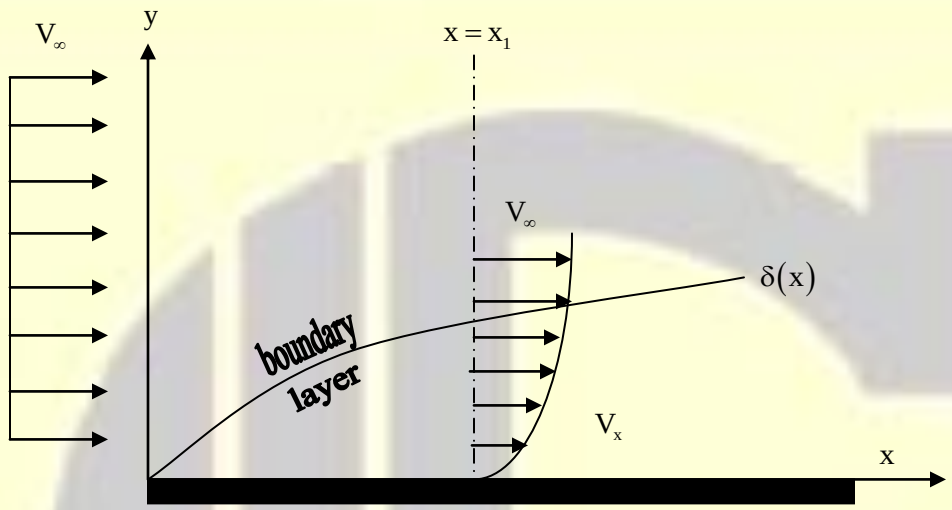
24. Water flows over a plate of finite length. At $x = x_1$ from the leading edge, the velocity of the flow is $V_x = 0.5y - 0.5y^3$. The thickness, δ (in meter) of the boundary layer at $x = x_1$ is: _____ (round off to 2 decimal places),

Given: V_∞ is the free stream velocity.



Answer: (0.53 to 0.59)

25. The vacancy concentration in a crystal doubles upon increasing the temperature from 27°C to 127°C. The enthalpy (in kJ mot1) of vacancy formation is: (round off to 2 decimal places).

Given: $R = 8.314\ J\ mol^{-1}K^{-1}$

Answer: (6.85 to 7.00)

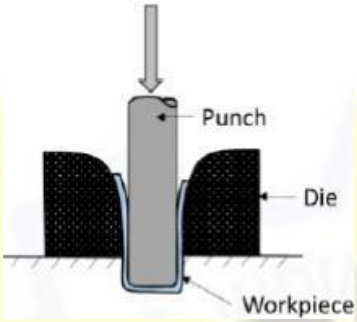
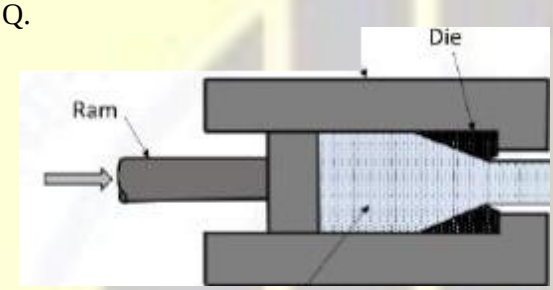
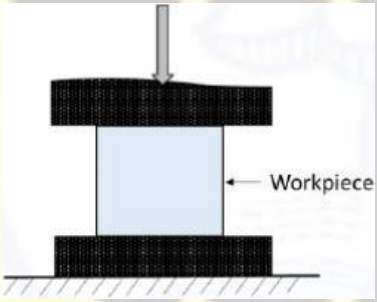
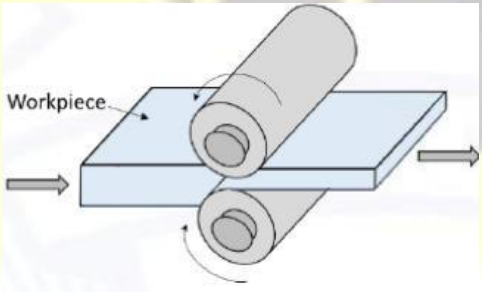
Q. No. 26-55 Carry Two Marks Each

26. The minimum value of y for the equation $y = x^2 - 2x + 4$ is _____

(A) 3 (B) 1 (C) 4 (D) 6

Answer: (A)

27. Match the forming process (in Column I) with its name (in Column II):

Column I	Column II
P. 	1. Extrusion
Q. 	2. Rolling
R. 	3. Deep Drawing
S. 	4. Open Die Forging

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

Answer: (B)

28. Match the nondestructive technique (in Column I) with its underlying phenomenon (in Column II):

Column I	Column II
P. Dye penetrant test	**1.** X-ray absorption
Q. Radiography	**2.** Capillary action
R. Eddy current test	**3.** Elastic waves reflection
S. Ultrasonic inspection	**4.** Electromagnetic induction

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

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

Answer: (C)

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29. Number of degrees of freedom for the following reacting system is: M (s) + CO_2 (g) = MO (s) + CO (g)

(A) 0 (B) 1 (C) 2 (D) 3

Answer: (C)

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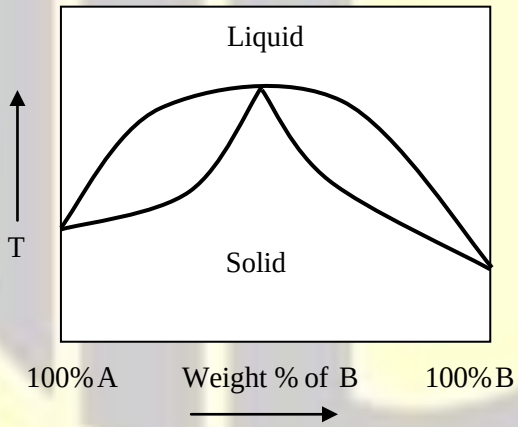
30. The condition for getting the binary phase diagram of A-B (shown below) is:



Given: ΔH_{mix}^{solid} – Enthalpy of mixing of solid

ΔH_{mix}^{liquid} – Enthalpy of mixing of liquid

(A) $\Delta H_{mix}^{solid} = 0$ and $\Delta H_{mix}^{liquid} = 0$ (B) $\Delta H_{mix}^{solid} << 0$ and $\Delta H_{mix}^{liquid} = 0$

(C) $\Delta H_{mix}^{solid} > 0$ and $\Delta H_{mix}^{liquid} = 0$ (D) $\Delta H_{mix}^{solid} = 0$ and $\Delta H_{mix}^{liquid} << 0$

Answer: (B)

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31. In the absence of any external stress, which one of the following statements related to the interaction of point defect and a dislocation is FALSE:

(A) An oversized solute atom would preferentially migrate below the slip plane of an edge dislocation.

(B) A spherically symmetric point defect can interact with both the hydrostatic and shear stress fields of a dislocation.

(C) A point defect can locally modify the elastic modulus and thereby can change the interaction energy.

(D) Vacancies are attracted towards the compressive region of dislocation.

Answer: (B)

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32. A single crystal aluminium sample is subjected to uniaxial tension along [112] direction. If the applied tensile stress is 100 MPa and the critical resolved shear stress (CRSS) is 25 MPa, which one of the following slip systems will be activated?

(A) $\left[\bar{1}01\right](111)$ (B) $\left[\bar{1}10\right](111)$ (C) $[101](11\bar{1})$ (D) $[011](11\bar{1})$

Answer: (A)

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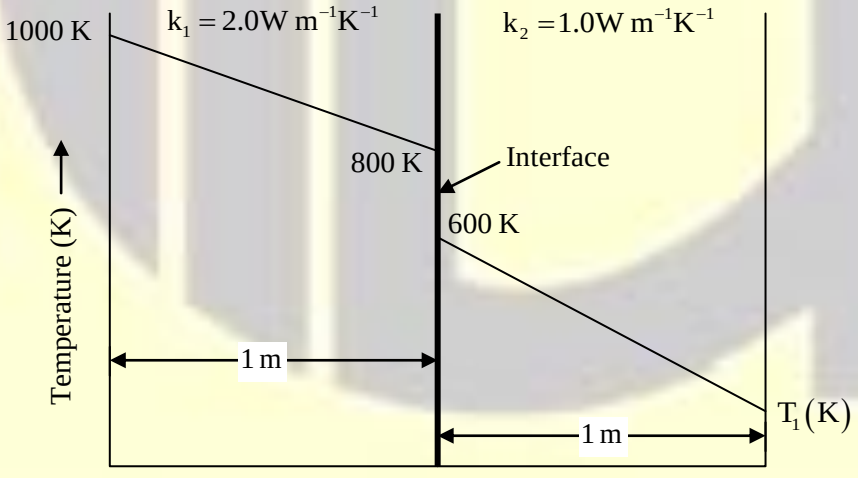
33. One-dimensional steady-state temperature distribution in two adjacent refractory blocks (with thermal conductivities, k_1 and k_2) of unit cross- sectional area are shown below. The temperature T_1 and thermal contact resistance of the interface, respectively, are:



(A) 200 K, 0.5 K W^{-1} (B) 400 K, 1.0 K W^{-1}

(C) 200 K, 0.25 K W^{-1} (D) 500K, 0.5 K W^{-1}

Answer: (A)

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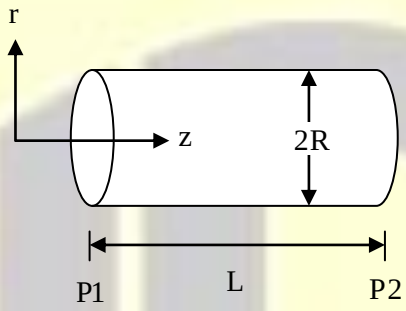
34. For a fully developed 1-D flow of a Newtonian fluid through a horizontal pipe of radius R (see figure), the axial velocity (v_z) is given by:

$$v_z = \left[\frac{\Delta P}{L}\right]\left(\frac{R^2 - r^2}{4\mu}\right),$$

where, ΔP is the pressure difference (P1-P2), μ is the viscosity, r is the radial distance from the axis and L is the length of the tube. The shear stress exerted by the fluid on the tube wall is:



(A) $\frac{\Delta PR}{2L}$ (B) $\frac{\Delta PR}{L}$ (C) $\frac{3\Delta PR}{2L}$ (D) $\frac{2\Delta PR}{L}$

Answer: (A)

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35. Match the terms (in Column I) with the unit process (in Column II)

Column I	Column II
P. Submerged Entry Nozzle	**1.** Ladle Furnace
Q. Electric Heating	**2.** Continuous Casting
R. Raceway Zone	**3.** LD Converter
S. Oxygen Lancing	**4.** Blast Furnace

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

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

Answer: (A)

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36. A blast furnace uses hematite ore with 80% Fe2<n and 20% gangue materials. It uses 600 kg coke per ton of hot metal. The coke contains 85% C and 15% ash. The composition of hot metal is 95.5% Fe and 4.5% C.

The weight of iron ore used and slag produced per ton of hot metal respectively, are:

Given: Atomic weight: O = 16, C = 12, N = 14, Fe = 56

All the compositions are in wt.%.

1 ton = 1000 kg

Assume that the gangue materials of the ore and ash content of coke form slag while Fe203 in the ore is consumed in making hot metal.

(A) 1705 kg, 431 kg
(B) 2131 kg, 546 kg
(C) 1705 kg, 331 kg
(D) 1500 kg, 431 kg

Answer: (A)

---

37. Consider the function $f(x) = x - \cos x$. Using Newton-Raphson method, the estimated root of f(x) after the first iteration is: (round off to 3 decimal places).

Assume: Initial guess of the root= 0.5 radians.

Answer: (0.745 to 0.770)

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38. The work done by a force F = 2xi + 3yj along a straight line from point (0, 0) to (1, 2) is:____ (round off to nearest integer).

Answer: (7 to 7)

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39. A coin is tossed three times. Given that there are more heads than tails, the probability of getting exactly one tail is: _____(round off to 2 decimal places).

Answer: (0.75 to 0.75)

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40. A continuous fillet weld is made using a 3000 W welding machine. At a travel speed of 6 mm s^{-1}, the cross-sectional area (in mm^2) of the weld is: _____ (round off to nearest integer).

Given: The unit energy required to melt the metal is 6 J mm'.

Heat transfer factor = 0.6

Melting factor = 0.5

Answer: (25 to 25)

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41. Liquid iron is cast into a spherical sand mold (6 cm radius) and a cubical sand mold (12 cm edge length). If solidification time is 60 minutes in the spherical casting, the time (in minutes) required to solidify in the cubical casting is: _____ (round off to nearest integer).

Answer: (58 to 62)

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42. True strain for 60% height reduction of a sample subjected to hot forging is: _____(round off to 2 decimal places).

Answer: (–0.94 to –0.90)

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43. For the equilibrium reaction: $2Cu(s)+SO_2(g)=Cu_2S(s)+O_2(g)$, the value of $\ell n\left(\frac{P_{O_2}}{P_{SO_2}}\right)$ at 973 K is: _____ (round off to 2 decimal places).

Given:

$2Cu(s)+0.5S_2(g)=Cu_2(s)$ $\quad \Delta G^\circ$ at 973 K = –100 kJ

$SO_2(g)=0.5S_2(g)+O_2(g)$ $\quad \Delta G^\circ$ at 973 K = 292 kJ

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

Assume: Cu and Cu_2S are pure solids.

Answer: (–24.00 to 23.50)

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44. One mole of an ideal gas at 10 atm. and 300 K undergoes reversible adiabatic expansion to a pressure of one atm. The work done (in Joule) by the gas is:_____ (round off to nearest integer).

Given: $R = 8.314\ J\ mol^{-1}K^{-1}; 1\ atm. = 101325\ Pa; Cp = 2.5R$

Answer: (2240 to 2256)

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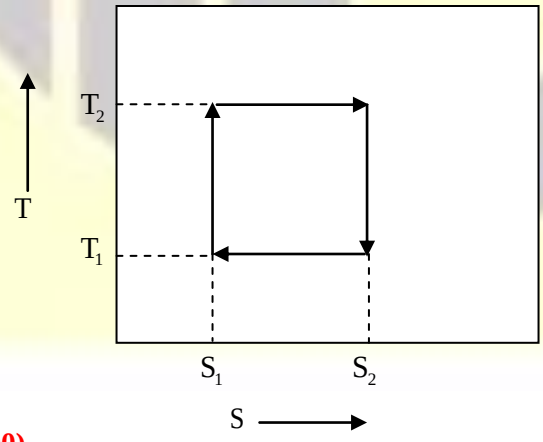
45. The figure shows the entropy versus temperature (S-T) plot of a reversible cycle of an engine. If $T_1 = 200$ K and $T_2 - 600$ K, the efficiency of the engine (in percent) is: _____(round off to 2 decimal places).



Answer: (63.00 to 71.00)

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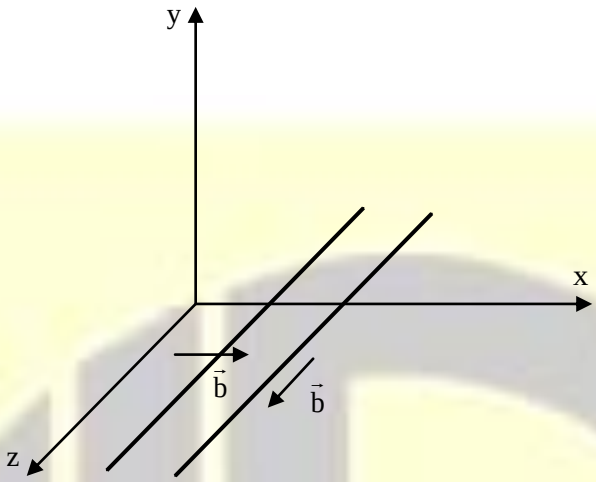
46. Two dislocation lines parallel to z-axis lying in the x-z plane are shown in the figure. The glide force (in Newton) exerted by the edge dislocation on the screw dislocation is: (round off to nearest integer).



For the edge, the shear stress component is given by:

$$\tau_{xy} = \frac{Gb}{2\pi(1-v)} \frac{x\left(x^2 - y^2\right)}{\left(x^2 + y^2\right)^2}$$

Given: Shear modulus, G = 28 GPa

Poisson's ratio, v = 0.3

Burgers vector, b = 0.29 nm

Distance between the two dislocations = 0.5 nm

Answer: (0 to 0)

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47. In a material, a shear stress of 100 MPa is required to bow a dislocation line between precipitates with a spacing of 0.2 μm. If the spacing between the precipitates is increased to 0.5 μm, the shear stress (in MPa) to bow the dislocation would be:____ (round off to nearest integer).

Answer: (40 to 40)

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48. A metal plate is in a state of plane strain $(\varepsilon_{zz} = 0)$ with $\sigma_{xx} = \sigma_{yy} \neq 0$ and $\tau_{xy} = \tau_{xz} = \tau_{yz} = 0$. If the Poisson's ratio is 0.3, the ratio, $\frac{\sigma_{zz}}{\sigma_{xx}}$ is _____ (round off to 1 decimal place).

Answer: (0.6 to 0.6)

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49. An infinite metal plate has a central through-thickness crack of length $\frac{80}{\pi}$ mm. The maximum applied stress (in MPa) that the plate can sustain in mode I is:_____ (round off to nearest integer).

Assume: Linear elastic fracture mechanics is valid

Given: Fracture toughness, $K_{IC} = 20\ \text{MPa}\,\text{m}^{1/2}$

Answer: (98 to 102)

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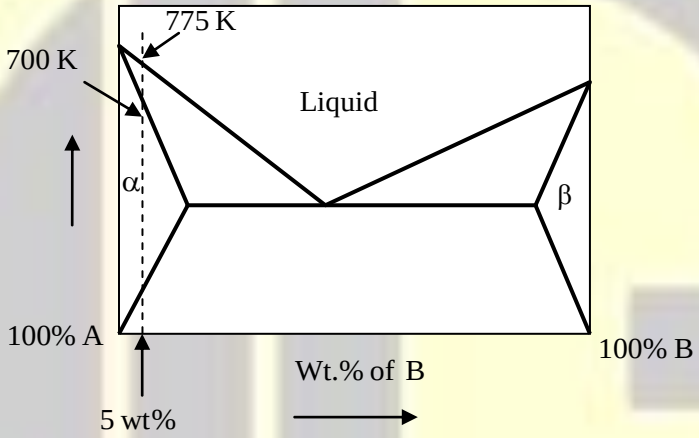
50. A hypothetical binary eutectic phase diagram of A–B is shown below. An alloy with 5 wt.% B solidifies with no convection. Assuming steady state, the critical temperature gradient (in K mm") required to maintain planar solidification front is: (round off to nearest integer).



Given: Diffusivity of B in liquid $= 10^{-9}\,\text{m}^2\text{s}^{-1}$

Velocity of solidification front $= 4\mu\text{ms}^{-1}$

Answer: (298 to 302)

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51. A thick steel plate containing 0.1 wt.% C is carburized at 950°C. The plate's surface carbon concentration is maintained at 1.1 wt.% C. After 9 hours, the depth (in mm) below the surface at which the carbon concentration is 0.6 wt.% C will be:_____ (round off to 2 decimal places).

Given: Diffusivity of carbon in γ-Fe at $950°\text{C} = 1.6\times10^{-11}\,\text{m}^2\text{s}^{-1}$

Error function table:

z	0.35	0.40	0.45	0.50	0.55	0.60
erf(z)	0.3794	0.4284	0.4755	0.5205	0.5633	0.6039

Answer: (0.65 to 0.75)

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52. At 25°C, iron corrodes in a deaerated acid of pH 3 with a corrosion current density of $4\,\mu A\,cm^{-2}$. The corrosion potential (V) is: _____ (round off to 2 decimal places).

Given: $\beta_c = 0.1\,V$ per decade of current density

Exchange current density of hydrogen on iron surface $= 10^{-9}\,A\,cm^{-2}$

$R = 8.314\,J\,mol^{-1}K^{-1}, F = 96500\,C\,mol^{-1}$

All potential are with reference to standard hydrogen electrode.

Answer: (–0.60 to –0.50)

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53. The radius of an interstitial atom which just fits (without distorting the structure) inside an octahedral void of a bcc-iron crystal (in nm) is: _____ (round off to 3 decimal places).

Assume the radius of Fe atom to be 0.124 nm.

Answer: (0.017 to 0.023)

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54. Nickel undergoes isothermal oxidation at 800 K for a duration of 400 s resulting in a weight gain of 2 mg cm^2.The weight gain ($mg\,cm^2$) after a duration of 1600 s is:____ (round off to nearest integer).

Assume: Weight gain is proportional to square root of time.

Answer: (4 to 4)

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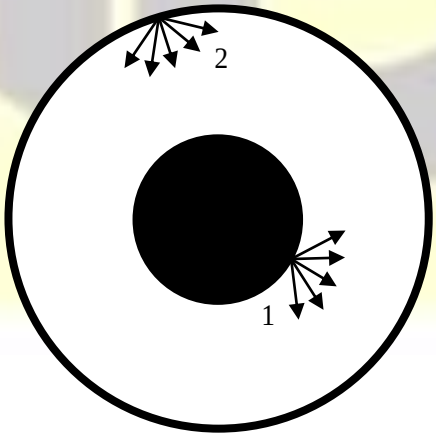
55. A solid sphere (0.5 m radius) is enclosed within a larger hollow sphere (1 m radius), as shown in figure. The radiation exchange takes place between the outer surface (surface 1) of the small sphere and the inner surface (surface 2) of the bigger sphere. The value of the view factor, F_{22} is: ____ (round off to 2 decimal places).

Given: View factor (F_{ij}) is the fraction of the radiation leaving surface i that is intercepted by surface j.



Answer: (074 to 0.75)
