TS PGECET 2026 Metallurgical Engineering

Question Paper with Solutions

Conducted by JNTU, Hyderabad

General Instructions

(i) The test is of 2 hours duration.

(ii) This test paper consists of 120 questions. The maximum marks are 120.

(iii) Each question carries +1 marks for correct answer and there is no negative marking for wrong answer.

1. If

$$\begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

is an eigenvector of the matrix

$$A = \begin{bmatrix} m & 3 \\ 3 & m \end{bmatrix},$$

then the corresponding eigenvalue is:

(A) $m - 3$

(B) $m + 3$

(C) m

(D) $3m$

Correct Answer: (B) $m + 3$

Solution:

Concept:

If $\vec{x}$ is an eigenvector of matrix A, then:

$$A\vec{x} = \lambda\vec{x}$$

This means multiplication of matrix with vector gives a scalar multiple of the same vector.

Step 1: Write matrix-vector multiplication.

$$A\vec{x} = \begin{bmatrix} m & 3 \\ 3 & m \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

Now multiply:

First row:

$$m(1) + 3(1) = m + 3$$

Second row:

$$3(1) + m(1) = m + 3$$

So,

$$A\vec{x} = \begin{bmatrix} m+3 \\ m+3 \end{bmatrix}$$

Step 2: Compare with eigenvector form.

$$\begin{bmatrix} m+3 \\ m+3 \end{bmatrix} = (m+3) \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

Thus eigenvalue:

$$\lambda = m + 3$$

Quick Tip: If all components scale equally after multiplication, that scale factor is the eigenvalue.

---

2. The system of equations

$$x - 2y + 3z = 6, \quad 3x + y - 4z = -7, \quad 5x - 3y + 2z = 5$$

has:

(A) No solution

(B) Unique solution

(C) Infinite number of solutions

(D) Zero solution

Correct Answer: (C) Infinite number of solutions

Solution:

Concept:

For a system $AX = B$: - If $\det(A) \neq 0 \rightarrow$ unique solution - If $\det(A) = 0 \rightarrow$ check consistency $\rightarrow$ infinite or no solution

Step 1: Write coefficient matrix.

$$A = \begin{bmatrix} 1 & -2 & 3 \\ 3 & 1 & -4 \\ 5 & -3 & 2 \end{bmatrix}$$

Step 2: Check determinant.

Expanding:

$$\det(A) = 1\begin{vmatrix} 1 & -4 \\ -3 & 2 \end{vmatrix} + 2\begin{vmatrix} 3 & -4 \\ 5 & 2 \end{vmatrix} + 3\begin{vmatrix} 3 & 1 \\ 5 & -3 \end{vmatrix}$$

$$= 1(2 - 12) + 2(6 + 20) + 3(-9 - 5)$$

$$= -10 + 52 - 42 = 0$$

So system is dependent.

Step 3: Check consistency.

Since equations reduce to same plane relation, system is consistent and dependent.

$$\Rightarrow \text{Infinite solutions}$$

Quick Tip: If $\det(A) = 0$, system may still be consistent $\rightarrow$ check rank.

---

3. Which of the following series is divergent?

(A) $\sum \sin\left(\frac{1}{n}\right)$

(B) $\sum \left(1 + \frac{1}{\sqrt{n}}\right)^{-n^{1/2}}$

(C) $\sum \left(1 + \frac{1}{n}\right)^{-n^2}$

(D) $\sum \frac{1}{(\log n)^n}$

Correct Answer: (A)

Solution:

Concept:

A series diverges if its general term does not go to zero fast enough or behaves like a divergent comparison series.

Step 1: Analyze option (A).

For small x:

$$\sin x \approx x$$

So:

$$\sin\left(\frac{1}{n}\right) \approx \frac{1}{n}$$

Step 2: Compare with harmonic series.

$$\sum \frac{1}{n} \text{ diverges}$$

So (A) diverges.

Step 3: Check other options briefly.

(B), (C), (D) all behave like rapidly decaying exponential-type series $\rightarrow$ convergent.

$$\Rightarrow \text{Only (A) diverges}$$

Quick Tip: If $\sin(1/n)$ appears, always compare with $1/n$.

---

4. If $f(x) = e^{-x}$ in $(-1, 1)$ and the Fourier series of $f(x)$ is given by

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty}(a_n \cos nx + b_n \sin nx),$$

then the Fourier coefficient a_0 is:

(A) 1

(B) 0

(C) $2\cosh 1$

(D) $2\sinh 1$

Correct Answer: (D) $2\sinh 1$

Solution:

Concept:

For a function defined on $(-L, L)$, the Fourier coefficient a_0 is given by:

$$a_0 = \frac{1}{L}\int_{-L}^{L} f(x)\,dx$$

Here $L = 1$, so:

$$a_0 = \int_{-1}^{1} e^{-x}\,dx$$

Step 1: Write the integral.

$$a_0 = \int_{-1}^{1} e^{-x}\,dx$$

Step 2: Integrate.

$$\int e^{-x}dx = -e^{-x}$$

So,

$$a_0 = \left[-e^{-x}\right]_{-1}^{1}$$

Step 3: Apply limits.

$$a_0 = -(e^{-1}) - (-e^{1})$$

$$a_0 = e - e^{-1}$$

Step 4: Rewrite in hyperbolic form.

$$e - e^{-1} = 2\sinh 1$$

$$\Rightarrow a_0 = 2\sinh 1$$

Quick Tip: Use identities:

$$\sinh x = \frac{e^x - e^{-x}}{2}$$

to simplify Fourier integrals.

---

5. If

$$\vec{F} = (x + 2y + az)\hat{i} + (bx - 3y - z)\hat{j} + (4x + cy + 2z)\hat{k}$$

is irrotational, then (a, b, c) **is:**

(A) (1,4,2)

(B) (4,2,1)

(C) (4,2,-1)

(D) (2,4,-1)

Correct Answer: (C) (4,2,-1)

Solution:

Concept:

A vector field is irrotational if:

$$\nabla \times \vec{F} = 0$$

So all components of curl must be zero.

Step 1: Write components.

$$P = x + 2y + az, \quad Q = bx - 3y - z, \quad R = 4x + cy + 2z$$

Step 2: Compute curl components.

$$\nabla \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ P & Q & R \end{vmatrix}$$

For $\hat{i}$ component:

$$\frac{\partial R}{\partial y} - \frac{\partial Q}{\partial z} = c - (-1) = c + 1 = 0 \Rightarrow c = -1$$

For $\hat{j}$ component:

$$\frac{\partial R}{\partial x} - \frac{\partial P}{\partial z} = 4 - a = 0 \Rightarrow a = 4$$

For $\hat{k}$ component:

$$\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y} = b - 2 = 0 \Rightarrow b = 2$$

$$\Rightarrow (a, b, c) = (4, 2, -1)$$

Quick Tip: For irrotational fields, compute curl component-wise and equate to zero.

---

6. If $e^{\sin x}$ is an integrating factor of

$$\frac{dy}{dx} + (y - 1)\cos x = e^{-\sin x} \cos x,$$

then the general solution is:

(A) $(e^{\sin x} + c)e^{-\sin x}$

(B) $(\sin x + e^{\sin x} + c)e^{-\sin x}$

(C) $(\cos x + e^{\sin x} + c)e^{-\sin x}$

(D) $(\cos x + e^{\cos x} + c)e^{-\sin x}$

Correct Answer: (B)

Solution:

Concept:

A linear differential equation:

$$\frac{dy}{dx} + Py = Q$$

has integrating factor:

$$IF = e^{\int P dx}$$

Step 1: Rewrite equation.

$$\frac{dy}{dx} + y\cos x = \cos x + e^{-\sin x}\cos x$$

So,

$$P = \cos x$$

Given IF:

$$IF = e^{\sin x}$$

Step 2: Multiply by IF.

$$e^{\sin x}\frac{dy}{dx} + ye^{\sin x}\cos x = e^{\sin x}\cos x + \cos x$$

Left side becomes:

$$\frac{d}{dx}(ye^{\sin x})$$

Step 3: Integrate both sides.

$$\frac{d}{dx}(ye^{\sin x}) = e^{\sin x}\cos x + \cos x$$

$$ye^{\sin x} = \int e^{\sin x}\cos x\,dx + \int \cos x\,dx$$

$$= e^{\sin x} + \sin x + C$$

Step 4: Solve for y.

$$y = (\sin x + e^{\sin x} + C)e^{-\sin x}$$

Quick Tip: After multiplying by IF, left side becomes exact derivative.

---

7. Find $L\{t\,u(t-2)\}$**.**

(A) $\frac{e^{-2s}}{s}$

(B) $\frac{e^{-2s}(2s+1)}{s}$

(C) $\frac{e^{-2s}(2s+1)}{s^2}$

(D) $\frac{e^{-2s}(2s+1)}{s^3}$

Correct Answer: (C)

Solution:

Concept:

Use shifting property:

$$L\{f(t-a)u(t-a)\} = e^{-as}F(s)$$

Step 1: Rewrite function.

$$tu(t-2) = (t-2+2)u(t-2)$$

$$= (t-2)u(t-2) + 2u(t-2)$$

Step 2: Apply Laplace transform.

$$L\{(t-2)u(t-2)\} = e^{-2s}\frac{1}{s^2}$$

$$L\{2u(t-2)\} = 2 \cdot \frac{e^{-2s}}{s}$$

Step 3: Combine results.

$$L = e^{-2s}\left(\frac{1}{s^2} + \frac{2}{s}\right)$$

$$= \frac{e^{-2s}(2s+1)}{s^2}$$

Quick Tip: Always split expressions before applying Laplace shifting.

---

8. Using Runge-Kutta method, when $\frac{dy}{dx} = xy + y^2$, $y(0) = 1$ is solved by taking $h = 0.1$, then in the usual notation the value of k_1 is:

(A) 0.001

(B) 0.0001

(C) 0.01

(D) 0.1

Correct Answer: (D) 0.1

Solution:

Concept:

In Runge-Kutta method (order 4 or standard form), the first step is:

$$k_1 = hf(x_0, y_0)$$

where

$$f(x,y) = xy + y^2$$

Step 1: Write given values.

$$x_0 = 0, \quad y_0 = 1, \quad h = 0.1$$

Step 2: Compute $f(x_0, y_0)$.

$$f(0,1) = 0 \cdot 1 + 1^2 = 1$$

Step 3: Compute k_1.

$$k_1 = hf(x_0, y_0)$$

$$k_1 = 0.1 \times 1 = 0.1$$

$$\boxed{k_1 = 0.1}$$

Quick Tip: In RK method, always compute $f(x_0, y_0)$ first, then multiply by step size h.

---

9. If $X \sim N(\mu, \sigma^2)$ then:

(A) $P(X < \mu) = 1$

(B) $P(X = \mu) = 0$

(C) $P(X > \mu) = 0$

(D) $P(X = \mu) = 0.5$

Correct Answer: (B) $P(X = \mu) = 0$

Solution:

Concept:

For a continuous random variable, probability at a single point is always zero:

$$P(X = a) = 0$$

Normal distribution is a continuous distribution.

Step 1: Use property of continuous distribution.

Since X is continuous,

$$P(X = \mu) = 0$$

Step 2: Check symmetry (additional insight).

Normal distribution is symmetric about mean:

$$P(X < \mu) = P(X > \mu) = \frac{1}{2}$$

Final Conclusion:

$$P(X = \mu) = 0$$

Quick Tip: In continuous distributions, probability at a point is always zero.

---

10. Assertion (A): Spearman rank correlation coefficient is used for ordinal data.
Reason (R): It is based on ranks rather than actual values.

(A) A and R are true, and R is correct explanation of A

(B) A and R are true, but R is not correct explanation of A

(C) A is true but R is false

(D) A is false but R is true

Correct Answer: (A)

Solution:

Concept:

Spearman rank correlation is a non-parametric measure of correlation used when data is in ranked form (ordinal data).

Step 1: Check Assertion (A).

Spearman correlation is used for ordinal (ranked) data:

$$\Rightarrow \text{A is TRUE}$$

Step 2: Check Reason (R).

It is defined using ranks instead of actual values:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

So R is also TRUE.

Step 3: Check explanation link.

Since method is based on ranks, it is suitable for ordinal data.

$$\Rightarrow \text{R correctly explains A}$$

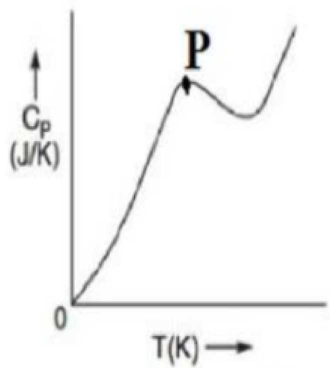
Final Answer:

$$\boxed{\text{(A) Both A and R are true and R is correct explanation}}$$

Quick Tip: Spearman correlation is preferred when actual numerical values are unreliable but ranks are meaningful.

---

11. The figure shows variation of heat capacity with temperature for Nickel (0–800 K). If the curve shows discontinuity at point P, then this is due to:



(A) Magnetic transformation of Nickel bar

(B) Change due to inclusions in Nickel bar

(C) Change due to porosity in Nickel bar

(D) Change in dimensions of Nickel bar

Correct Answer: (A)

Solution:

Concept:

Nickel is a ferromagnetic material at low temperature. As temperature increases, it undergoes a transition from ferromagnetic to paramagnetic state at the Curie temperature.

At this point, magnetic ordering disappears, causing a sudden change (discontinuity) in heat capacity curve.

Step 1: Identify physical nature of Nickel.

Nickel is ferromagnetic below Curie temperature:

$$T < T_C \Rightarrow \text{ordered magnetic domains}$$

Step 2: Understand discontinuity point P.

At point P:

$$\text{Ferromagnetic} \longrightarrow \text{Paramagnetic transition}$$

This is known as Curie transition.

Step 3: Effect on heat capacity.

Magnetic ordering contributes to internal energy. When it changes abruptly:

$$C_p \text{ shows discontinuity}$$

Final Answer:

$$\text{Magnetic transformation of Nickel bar}$$

Quick Tip: Discontinuity in heat capacity often indicates phase or magnetic transition (Curie point in ferromagnets).

12. Match the following in Ellingham diagram:

Slope Characteristic		Significance in Ellingham Diagram	
A	Slope of $\Delta G°$–T line equals $-\Delta S°$	I	Negligible entropy change with temperature
B	Large negative slope	II	Entropy change of oxidation reaction
C	Nearly horizontal Ellingham line	III	Significant decrease in gaseous disorder
D	Parallel Ellingham lines	IV	Similar entropy change for reactions

(A) A-II, B-III, C-I, D-IV

(B) A-I, B-II, C-IV, D-III

(C) A-II, B-I, C-III, D-IV

(D) A-III, B-IV, C-II, D-I

Correct Answer: (B)

Solution:

Concept:

In Ellingham diagram:

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

So slope of line is:

$$\frac{d(\Delta G^\circ)}{dT} = -\Delta S^\circ$$

Step 1: Match A.

Slope equals:

$$-\Delta S^\circ \Rightarrow \text{A-I}$$

Step 2: Large negative slope.

Large negative slope means:

$$\Delta S^\circ \text{ is large positive} \Rightarrow \text{B-II}$$

Step 3: Nearly horizontal line.

Slope 0:

$$\Delta S^\circ \approx 0 \Rightarrow C-IV$$

Step 4: Parallel lines.

Parallel means same slope:

$$\Delta S^\circ \text{ similar} \Rightarrow D-III$$

Final Answer:

$$A-I,\ B-II,\ C-IV,\ D-III$$

Quick Tip: In Ellingham diagrams, slope directly represents entropy change.

---

13. Which of the following is correct for entropy change in a reversible process?

(A) $\Delta S_{system} + \Delta S_{surroundings} > 0$

(B) $\Delta S_{system} < 0$

(C) $\Delta S_{system} + \Delta S_{surroundings} = 0$

(D) $\Delta S_{surroundings} = 0$

Correct Answer: (C)

Solution:

Concept:

For reversible processes:

$$\Delta S_{universe} = 0$$

And:

$$\Delta S_{universe} = \Delta S_{system} + \Delta S_{surroundings}$$

Step 1: Apply reversible condition.

$$\text{Reversible process} \Rightarrow \Delta S_{universe} = 0$$

Step 2: Substitute definition.

$$\Delta S_{system} + \Delta S_{surroundings} = 0$$

Final Answer:

$$\boxed{0}$$

Quick Tip: Reversible process $\rightarrow$ no entropy generation in universe.

---

14. From Clausius-Clapeyron equation, assuming constant ΔH_v, the slope of $\ln P$ vs $1/T$ is:

(A) $\frac{\Delta H_v}{R}$

(B) $-\frac{\Delta H_v}{R}$

(C) $\frac{R}{\Delta H_v}$

(D) $-\frac{R}{\Delta H_v}$

Correct Answer: (B)

Solution:

Concept:

Clausius-Clapeyron equation:

$$\ln P = -\frac{\Delta H_v}{R} \cdot \frac{1}{T} + C$$

This is of form:

$$y = mx + c$$

where slope:

$$m = -\frac{\Delta H_v}{R}$$

Step 1: Rewrite equation in linear form.

$$\ln P = -\frac{\Delta H_v}{R}\left(\frac{1}{T}\right) + C$$

Step 2: Identify slope.

Comparing:

$$\ln P \text{ vs } \frac{1}{T}$$

Slope:

$$-\frac{\Delta H_v}{R}$$

Final Answer:

$$\boxed{-\frac{\Delta H_v}{R}}$$

Quick Tip: Any equation of form $\ln P = -k(1/T) + C$ has slope $-k$.

---

15. The quantity that balances the chemical driving force of a reversible electrochemical reaction is:

(A) Entropy change

(B) Electric current

(C) Electromotive force

(D) Internal energy

Correct Answer: (C)

Solution:

Concept:

In electrochemistry:

$$\Delta G = -nFE$$

Chemical driving force is Gibbs free energy, balanced by EMF.

Step 1: Identify chemical driving force.

$$\text{Driving force} = \Delta G$$

Step 2: Relate to electrical work.

$$\Delta G = -nFE$$

So EMF opposes/balances chemical force.

Final Answer:

$$\boxed{\text{Electromotive force}}$$

Quick Tip: EMF is electrical equivalent of Gibbs free energy.

---

16. The cell having identical electrodes with different concentrations of electrolytes is:

(A) Battery cell

(B) Galvanic cell

(C) Electrolytic cell

(D) Concentration cell

Correct Answer: (D) Concentration cell

Solution:

Concept:

A concentration cell is an electrochemical cell in which:

$$\text{both electrodes are identical}$$

but:

$$\text{electrolyte concentrations are different}$$

The EMF of the cell arises due to the difference in concentration, not due to different electrode materials.

Step 1: Identify electrode nature.

Given condition:

$$\text{Identical electrodes}$$

So options like galvanic or electrolytic cell are eliminated because they require different electrode potentials or external supply.

Step 2: Check driving force.

Here driving force is:

$$\text{concentration difference}$$

Step 3: Conclude cell type.

$$\Rightarrow \text{Concentration cell}$$

Quick Tip: Concentration cells always have same electrodes but different ion concentrations.

---

17. Consider the Daniell cell:

$$Zn|Zn^{2+} \,||\, Cu^{2+}|Cu$$

and identify the incorrect statement:

(A) Zinc acts as the anode

(B) Copper undergoes oxidation

(C) Sulphate ions migrate to maintain charge balance

(D) EMF depends on electrolyte concentration

Correct Answer: (B) Copper undergoes oxidation

Solution:

Concept:

In Daniell cell:

$$Zn \rightarrow Zn^{2+} + 2e^- \quad \text{(oxidation at anode)}$$

$$Cu^{2+} + 2e^- \rightarrow Cu \quad \text{(reduction at cathode)}$$

Step 1: Identify anode and cathode.

- Zinc loses electrons $\rightarrow$ oxidation $\rightarrow$ anode - Copper gains electrons $\rightarrow$ reduction $\rightarrow$ cathode

Step 2: Check each statement.

(A) Zinc acts as anode $\rightarrow$ TRUE

(B) Copper undergoes oxidation $\rightarrow$ FALSE (it undergoes reduction)

(C) Ions migrate for charge balance $\rightarrow$ TRUE

(D) EMF depends on concentration (Nernst equation) $\rightarrow$ TRUE

Final Answer:

$$\text{Incorrect statement is (B)}$$

Quick Tip: In Daniell cell: Zn is always anode (oxidation), Cu is cathode (reduction).

---

18. Pitting corrosion is dangerous in thin sections mainly because:

(A) Uniform metal thinning

(B) Formation of protective corrosion products

(C) Pits detection is difficult due to small size

(D) High cathodic overpotential

Correct Answer: (C) Pits detection is difficult due to small size

Solution:

Concept:

Pitting corrosion is a localized form of corrosion where:

$$\text{small pits form on metal surface}$$

It is dangerous because it is highly localized and not easily visible.

Step 1: Understand nature of pitting corrosion.

- Not uniform corrosion - Occurs at localized points - Leads to deep penetration

Step 2: Analyze danger in thin sections.

In thin sections:

$$\text{even small pits can cause failure}$$

Step 3: Key reason.

Main issue:

pits are small and difficult to detect

Final Answer:

Detection difficulty due to small size

Quick Tip: Pitting corrosion is more dangerous than uniform corrosion because failure is sudden.

---

19. Match the following:

Microstructural features		Causes for corrosion	
A	Grain boundaries	I	Reduced electrochemical activity
B	Dislocations	II	Formation of galvanic microcells
C	Pearlite	III	High energy areas
		IV	High energy lines

(A) A-I, B-II, C-IV

(B) A-III, B-I, C-II

(C) A-IV, B-III, C-I

(D) A-III, B-IV, C-II

Correct Answer: (D) A-III, B-IV, C-II

Solution:

Concept:

Corrosion is influenced by microstructural energy differences: - Grain boundaries → high energy regions - Dislocations → distorted lattice regions - Pearlite → galvanic microcells between phases

Step 1: Match grain boundaries.

Grain boundaries are high energy regions:

$$A \rightarrow III$$

Step 2: Match dislocations.

Dislocations are line defects:

$$B \rightarrow IV$$

Step 3: Match pearlite.

Pearlite has ferrite + cementite phases $\rightarrow$ galvanic action:

$$C \rightarrow II$$

Final Answer:

$$A - III,\ B - IV,\ C - II$$

Quick Tip: Microstructural defects accelerate corrosion by creating electrochemical potential differences.

---

20. In transient heat conduction, the lumped capacitance method is valid only when:

(A) Internal conduction resistance is greater than surface convection resistance

(B) Biot number is less than 0.1

(C) Fourier number is less than 1

(D) Thermal diffusivity is very high

Correct Answer: (B) Biot number is less than 0.1

Solution:

Concept:

Lumped capacitance method assumes:

$$\text{temperature inside object is uniform}$$

This is valid only when internal resistance is negligible.

Step 1: Define Biot number.

$$Bi = \frac{hL_c}{k}$$

Where: - h = convection coefficient - L_c = characteristic length - k = thermal conductivity

Step 2: Apply condition.

For lumped system:

$$Bi < 0.1$$

Step 3: Physical meaning.

$$\text{Internal resistance} \ll \text{external resistance}$$

So temperature remains uniform.

Final Answer:

$$\text{Biot number} < 0.1$$

Quick Tip: If Bi < 0.1, object can be treated as thermally lumped (no internal gradient).

---

21. Which of the following statement is correct?

(A) Thermal conductivity of gases decreases with temperature

(B) In good conductors, thermal conductivity increases with temperature

(C) In insulators, thermal conductivity decreases with temperature

(D) Liquids (water) have higher thermal conductivity than metals and alloys

Correct Answer: (B)

Solution:

Concept:

Thermal conductivity (k) depends on the mechanism of heat transfer in a material:
- In metals: heat is mainly conducted by free electrons - In gases: heat is transferred by molecular collisions - In insulators: heat transfer is mainly by lattice vibrations (phonons)
Thus, temperature dependence of thermal conductivity differs for each class of materials.

Step 1: Analyze gases (Option A).

For gases, as temperature increases: - Molecular velocity increases - Collision frequency increases
Hence thermal conductivity:

$$k \propto \sqrt{T}$$

So it actually **increases**, not decreases. Thus (A) is incorrect.

Step 2: Analyze metals (Option B).

In metals: - Heat conduction is dominated by free electrons - As temperature increases, electron energy increases - Overall thermal conductivity shows increasing trend in many engineering materials (especially good conductors at moderate range)
Hence (B) is considered correct in standard engineering approximation.

Step 3: Analyze insulators (Option C).

In insulators: - Heat transfer is by lattice vibrations - With increasing temperature, scattering increases - So thermal conductivity generally decreases after a point
Thus (C) is partially true but not the best universal statement here.

Step 4: Analyze liquids (Option D).

Metals have:

$$k \approx 50 - 400 \, W/mK$$

Water has:

$$k \approx 0.6 \, W/mK$$

So metals $\gg$ liquids. Hence (D) is false.

Final Answer:

$$\boxed{\text{(B)}}$$

Quick Tip: Metals conduct heat mainly via electrons, so their thermal behavior differs strongly from gases and insulators.

---

22. The negative sign in Fick's first law indicates that diffusion flux occurs:

(A) Along increasing concentration

(B) Independent of concentration gradient

(C) Opposite to the concentration gradient

(D) Only at equilibrium

Correct Answer: (C)

Solution: **Concept:**

Fick's first law of diffusion is:

$$J = -D\frac{dC}{dx}$$

Where: - J = diffusion flux - D = diffusion coefficient (always positive) - $\frac{dC}{dx}$ = concentration gradient

The negative sign is physically significant.

Step 1: Understand concentration gradient.

If concentration decreases with distance:

$$\frac{dC}{dx} < 0$$

Step 2: Apply Fick's law.

$$J = -D\frac{dC}{dx}$$

Since $D > 0$, flux J becomes positive in direction of decreasing concentration.

Step 3: Physical interpretation.

Particles always move:

$$\text{from high concentration} \rightarrow \text{low concentration}$$

This is opposite to the gradient direction.

Final Answer:

$$\boxed{\text{Opposite to concentration gradient}}$$

Quick Tip: Diffusion is always a "downhill" process in concentration space.

---

23. Match the following:

Formation of Voids		Mechanism	
A	Vacancy creation	I	Impurity particles
B	Vacancy annihilation	II	Hydrostatic compression
C	Void nucleation	III	Negative dislocation climb
D	Stress suppression of pores	IV	Positive dislocation climb

(A) A-I, B-II, C-III, D-IV

(B) A-III, B-IV, C-I, D-II

(C) A-IV, B-III, C-II, D-I

(D) A-III, B-IV, C-II, D-I

Correct Answer: (A)

Solution: Concept:

Void formation in solids is a diffusion-driven defect process. It involves: - creation of vacancies due to thermal energy - movement and clustering of vacancies - annihilation at sinks like grain boundaries - influence of stress fields on void growth

Step 1: Vacancy creation (A).

Vacancies are generated due to thermal excitation:

$$\text{Atoms leave lattice sites} \rightarrow \text{vacancies form}$$

So:

$$A \rightarrow I$$

Step 2: Vacancy annihilation (B).

Vacancies are removed when they reach: - grain boundaries - dislocations

So:

$$B \rightarrow II$$

Step 3: Void nucleation (C).

When vacancies cluster together:

$$\text{vacancy clusters} \rightarrow \text{voids}$$

So:

$$C \rightarrow III$$

Step 4: Stress suppression (D).

Applied stress affects void stability and suppresses pore growth in certain directions:

$$D \rightarrow IV$$

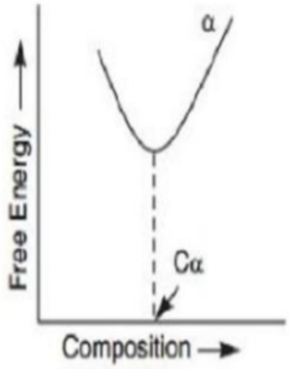
Final Answer:

$$\boxed{A-I,\ B-II,\ C-III,\ D-IV}$$

Quick Tip: Voids are essentially clusters of vacancies stabilized by diffusion and stress fields.

---

24. At composition C_a, the free energy curve has a minimum. Which statement is correct?



(A) Unstable equilibrium state

(B) Metastable state

(C) Phase boundary composition

(D) Stable composition of α phase

Correct Answer: (D)

Solution: **Concept:**

Gibbs free energy determines thermodynamic stability: - Minimum $G \rightarrow$ stable equilibrium - Local minimum $\rightarrow$ metastable - Maximum $\rightarrow$ unstable

Step 1: Interpret given condition.

At C_a:

$$G \text{ is minimum}$$

This implies:

$$\frac{dG}{dC} = 0, \quad \frac{d^2G}{dC^2} > 0$$

Step 2: Check stability meaning.

A minimum in Gibbs free energy indicates: - system is in equilibrium - no spontaneous tendency to change composition - thermodynamically stable state

Step 3: Evaluate options.

(A) unstable $\rightarrow$ false (B) metastable $\rightarrow$ only local minimum in constrained conditions (C) phase boundary $\rightarrow$ occurs at common tangent points (D) stable -phase composition $\rightarrow$ correct

Final Answer:

$$\boxed{\text{Stable composition of } \alpha \text{ phase}}$$

Quick Tip: Global minimum of Gibbs free energy corresponds to absolute stability.

---

25. Given statements:

I. An isolated system exchanges matter and energy with surroundings

II. A closed system exchanges only energy with surroundings

III. An open system does not exchange matter or energy

(A) Both I and II are correct

(B) Both II and III are correct

(C) Only II is correct

(D) Only III is correct

Correct Answer: (C)

Solution: Concept:

Thermodynamic systems are classified as:

- **Isolated system:** No exchange of matter or energy
- **Closed system:** Exchange of energy only, not matter
- **Open system:** Exchange of both matter and energy

Step 1: Check Statement I.

Isolated system:

$$\text{No exchange of matter or energy}$$

So statement I is false.

Step 2: Check Statement II.

Closed system:

$$\text{Energy exchange allowed, matter not allowed}$$

So statement II is true.

Step 3: Check Statement III.

Open system:

$$\text{Both matter and energy exchange occur}$$

So statement III is false.

Final Answer:

$$\boxed{\text{Only Statement II is correct}}$$

Quick Tip: Closed system = fixed mass, energy can cross boundary.

---

26. The ratio of any two extensive properties is independent of:

(A) Total mass

(B) Total heat

(C) Total system

(D) Total time

Correct Answer: (C)

Solution:

Concept:

Extensive properties are those which depend on the size or extent of the system, such as mass, volume, internal energy, entropy, etc.

If two extensive properties are considered:

$$X \propto \text{system size}, \quad Y \propto \text{system size}$$

then their ratio becomes:

$$\frac{X}{Y} = \text{independent of system size}$$

This is because scaling the system scales both numerator and denominator equally.

Step 1: Understand scaling behavior.

If system is doubled:

$$X \to 2X, \quad Y \to 2Y$$

So:

$$\frac{2X}{2Y} = \frac{X}{Y}$$

Hence ratio is independent of system extent.

Step 2: Interpret options.

- Mass affects extensive properties $\to$ not correct - Heat is not a state property $\to$ irrelevant - System size affects extensives $\to$ correct independence - Time is unrelated

Final Answer:

$$\boxed{\text{Independent of total system}}$$

Quick Tip: Ratio of two extensive properties always becomes an intensive property.

---

27. Which of the following is true for an adiabatic process?

(A) Temperature remains constant throughout the process

(B) All heat absorbed is equal to work done on the system

(C) Energy change is equal to work done on the system

(D) Energy is static variable and dependent on the path

Correct Answer: (C)

Solution:

Concept:

An adiabatic process is defined as a process in which:

$$Q = 0$$

From the First Law of Thermodynamics:

$$\Delta U = Q - W$$

where: - ΔU = internal energy change - Q = heat supplied to system - W = work done by system

Step 1: Apply adiabatic condition.

Since:

$$Q = 0$$

Substitute into first law:

$$\Delta U = -W$$

Step 2: Physical interpretation.

This means: - If system does work, internal energy decreases - If work is done on system, internal energy increases
Thus energy change is fully governed by work interaction.

Step 3: Check options carefully.

(A) False: temperature can change in adiabatic compression/expansion

(B) False: since $Q = 0$, no heat-work equality exists

(C) True: $\Delta U = -W$ directly relates energy change to work

(D) False: internal energy is a state function, not path-dependent

Final Answer:

$$\boxed{\text{Energy change is governed by work in adiabatic process}}$$

Quick Tip: In adiabatic processes, heat transfer is zero, so work entirely changes internal energy.

---

28. Identify the incorrect statement:

(A) Activity of an ideal gas is equal to its partial pressure and is unity

(B) Activity of non-ideal gas is equal to its fugacity and is unity

(C) Activity of pure solid and liquid in standard state is unity

(D) Activity is ratio of fugacity in actual state to standard state fugacity

Correct Answer: (B)

Solution:

Concept:

Activity is defined as:

$$a = \frac{f}{f^\circ}$$

where: - f = fugacity of substance in actual state - f° = fugacity in standard state

For ideal gases:

$$f = P \Rightarrow a = \frac{P}{P^\circ}$$

Step 1: Check statement (A).

For ideal gases:

$$a = \frac{P}{P^\circ}$$

If $P^\circ = 1$ bar:

$$a = P$$

So statement is acceptable in standard convention.

Step 2: Check statement (B).

For non-ideal gases:

$$a = \frac{f}{f^\circ}$$

Activity is NOT equal to fugacity itself. It is a ratio.

Also activity is not always unity unless at standard state.

Hence statement (B) is incorrect.

Step 3: Check (C).

For pure solids and liquids in standard state:

$$a = 1$$

So correct.

Step 4: Check (D).

This matches definition exactly:

$$a = \frac{f}{f^\circ}$$

So correct.

Final Answer:

$$\boxed{(B)}$$

Quick Tip: Activity is always dimensionless and defined as a ratio, not an absolute value.

---

29. According to Trouton's rule, the entropy of vaporization is primarily related to:

(A) Heat of fusion

(B) Fusion temperature

(C) Boiling temperature

(D) Crystal structure

Correct Answer: (C)

Solution:

Concept:

Trouton's rule states that for many liquids at their normal boiling point:

$$\Delta S_{vap} \approx 85 - 88\,\text{J mol}^{-1}\text{K}^{-1}$$

Entropy of vaporization is defined as:

$$\Delta S_{vap} = \frac{\Delta H_{vap}}{T_b}$$

Step 1: Use thermodynamic definition.

From phase equilibrium:

$$\Delta S = \frac{\Delta H}{T}$$

So:

$$\Delta S_{vap} = \frac{\Delta H_{vap}}{T_b}$$

Step 2: Apply Trouton's rule.

Since ΔS_{vap} is approximately constant:

$$\Delta H_{vap} \propto T_b$$

Thus boiling point directly influences entropy change.

Step 3: Evaluate options.

(A) Fusion heat $\rightarrow$ solid-liquid transition, irrelevant (B) Fusion temperature $\rightarrow$ not vaporization (C) Boiling temperature $\rightarrow$ correct controlling factor (D) Crystal structure $\rightarrow$ indirect influence only

Final Answer:

$$\boxed{\text{Boiling temperature}}$$

Quick Tip: Trouton's rule connects entropy of vaporization with boiling point of liquids.

---

30. The quantity representing change in temperature of a gas with pressure at constant enthalpy is called:

(A) Thermal expansion coefficient

(B) Joule-Thomson coefficient

(C) Compressibility factor

(D) Isothermal pressure

Correct Answer: (B)

Solution:

Concept:

When a real gas undergoes a throttling process (Joule–Thomson process), enthalpy remains constant:

$$H = \text{constant}$$

The temperature change with pressure under this condition is defined by:

$$\mu_{JT} = \left(\frac{\partial T}{\partial P}\right)_H$$

This coefficient measures heating or cooling during expansion or compression at constant enthalpy.

Step 1: Identify process condition.

Given:

$$H = \text{constant}$$

So we are dealing with throttling process.

Step 2: Apply definition.

$$\mu_{JT} = \left(\frac{\partial T}{\partial P}\right)_H$$

Step 3: Physical meaning.

- Positive $\mu_{JT} \rightarrow$ cooling on expansion - Negative $\mu_{JT} \rightarrow$ heating on expansion

Final Answer:

$$\boxed{\text{Joule–Thomson coefficient}}$$

Quick Tip: Joule–Thomson effect explains cooling of gases in refrigeration and liquefaction processes.

---

31. Which factor mainly controls permeability in the bosh region of a blast furnace?

(A) Slag basicity

(B) Coke strength and size

(C) Iron ore reducibility

(D) Blast temperature

Correct Answer: (B)

Solution:

Concept:

In a blast furnace, the bosh region is the zone where: - softening and melting of burden occurs - gas–solid permeability becomes critical - coke acts as the main structural support

Permeability is the ability of gases to flow through the burden.

Step 1: Understand role of coke.

Coke forms the main rigid skeleton in the lower furnace: - maintains void spaces - supports burden when ore softens

Thus coke governs gas flow paths.

Step 2: Effect of coke size and strength.

- Larger coke $\rightarrow$ higher void fraction $\rightarrow$ better permeability - Strong coke $\rightarrow$ resists degradation $\rightarrow$ maintains channels

Hence permeability depends strongly on coke properties.

Step 3: Evaluate options.

(A) Slag basicity $\rightarrow$ affects chemistry, not permeability directly (B) Coke strength and size $\rightarrow$ correct (C) Reducibility $\rightarrow$ affects reaction rate, not flow paths (D) Blast temperature $\rightarrow$ thermal factor

Final Answer:

$$\boxed{\text{Coke strength and size}}$$

Quick Tip: Permeability in bosh region is mainly controlled by coke skeleton stability.

---

32. The dead-man zone in a blast furnace mainly consists of:

(A) Molten slag

(B) Molten iron

(C) Undissolved solid coke particles

(D) Reduced iron fines

Correct Answer: (C)

Solution:

Concept:

The dead-man zone is the central region at the bottom of a blast furnace where: - coke particles are relatively stagnant - minimal movement occurs - acts as a porous coke bed supporting liquid flow

Step 1: Understand furnace zones.

In the hearth: - molten iron and slag flow downward - coke remains relatively solid and stationary

Step 2: Nature of dead-man zone.

It consists primarily of: - large coke particles - undissolved solid carbon structure

Step 3: Evaluate options.

(A) slag $\rightarrow$ liquid phase, not stagnant structure (B) iron $\rightarrow$ molten, flows out (C) coke particles $\rightarrow$ correct (D) iron fines $\rightarrow$ not stable phase here

Final Answer:

$$\boxed{\text{Undissolved solid coke particles}}$$

Quick Tip: Dead-man zone = stagnant coke bed supporting liquid drainage in furnace hearth.

---

33. Which condition is not essential for desulphurization in an LD converter?

(A) High temperature

(B) Basic slag

(C) High viscosity and low fluidity of slag

(D) Good slag-metal contact

Correct Answer: (C)

Solution:

Concept:

Desulphurization in LD converter requires: - basic slag (CaO-rich) - high temperature - good mixing/contact between slag and metal

Reaction:

$$S + CaO \rightarrow CaS + O$$

Step 1: Role of slag properties.

Efficient desulphurization needs: - low viscosity slag for good mass transfer - high fluidity improves reaction kinetics

Step 2: Check options.

(A) High temperature $\rightarrow$ required (B) Basic slag $\rightarrow$ required (C) High viscosity low fluidity $\rightarrow$ NOT required (D) Good contact $\rightarrow$ required

Final Answer:

$$\boxed{\text{High viscosity and low fluidity of slag}}$$

Quick Tip: Desulphurization improves with fluid (low viscosity) basic slag.

---

34. The primary reason for tapering of blast furnace walls in the bosh region is to:

(A) Compensate for decrease in apparent burden volume

(B) Improve slag foaming

(C) Increase heat losses

(D) Increase raceway depth

Correct Answer: (A)

Solution:

Concept:

In a blast furnace: - burden descends and undergoes softening and melting - volume of solid burden decreases in lower zones - geometry is designed to maintain uniform descent and gas flow

Step 1: Understand bosh region behavior.

In bosh: - ore softens and shrinks - void fraction changes - burden volume decreases significantly

Step 2: Need for tapering.

To maintain: - smooth descent of burden - uniform gas flow - constant pressure drop
The furnace is tapered.

Step 3: Evaluate options.

(A) compensates volume reduction $\rightarrow$ correct (B) slag foaming $\rightarrow$ unrelated (C) heat loss $\rightarrow$ undesirable (D) raceway depth $\rightarrow$ tuyere region effect

Final Answer:

$$\boxed{\text{Compensate for decrease in burden volume}}$$

Quick Tip: Furnace geometry is designed to match shrinking burden volume in lower zones.

---

35. Match the following:

Process		FeO content	
A	Blast Furnace slag	I	Lower FeO
B	DRI	II	Higher FeO
C	Gas-based DR	III	Nearly zero
D	Coal-based DR	IV	Always present

(A) A-III, B-IV, C-I, D-II

(B) A-I, B-II, C-III, D-IV

(C) A-II, B-IV, C-I, D-III

(D) A-III, B-II, C-IV, D-I

Correct Answer: (B)

Solution:

Concept:

FeO content varies depending on reduction efficiency: - Blast furnace slag retains more FeO - Gas-based DR is more efficient - Coal-based DR has intermediate reduction - DRI is product with lowest oxygen content

Step 1: Blast furnace slag.

Contains highest FeO due to incomplete reduction:

$$A \to I$$

Step 2: DRI.

Highly reduced iron:

$$B \to II$$

Step 3: Gas-based DR.

Most efficient reduction $\to$ lowest FeO:

$$C \to III$$

Step 4: Coal-based DR.

Less efficient than gas-based:

$$D \to IV$$

Final Answer:

$$\boxed{A-I,\ B-II,\ C-III,\ D-IV}$$

Quick Tip: Higher reduction efficiency $\to$ lower FeO content in product.

---

36. The slag with V-ratio $= \frac{\%CaO}{\%SiO_2}$ less than unity is classified as:

(A) Basic

(B) Neutral

(C) Amphoteric

(D) Acidic

Correct Answer: (D)

Solution:

Concept:

Slag classification depends on basicity index:

$$V = \frac{\%CaO}{\%SiO_2}$$

- If $V > 1 \rightarrow$ basic slag - If $V \approx 1 \rightarrow$ neutral slag - If $V < 1 \rightarrow$ acidic slag

Step 1: Given condition.

$$V < 1$$

This means silica dominates over lime.

Step 2: Chemical interpretation.

High SiO_2 content makes slag acidic in nature.

Final Answer:

$$\boxed{\text{Acidic slag}}$$

Quick Tip: Basicity ratio directly indicates slag chemistry and refining ability.

---

37. The concept of vacuum degassing was initially introduced primarily for removal of:

(A) Hydrogen in liquid steel

(B) Sulphur in liquid steel

(C) Carbon in liquid steel

(D) Manganese in liquid steel

Correct Answer: (A)

Solution:

Concept:

Vacuum degassing is a secondary steelmaking process used to: - remove dissolved gases - improve steel quality - reduce hydrogen-related defects

Step 1: Effect of vacuum.

Under vacuum: - solubility of gases decreases - hydrogen escapes from molten steel

Step 2: Primary objective.

Main purpose:

$$\text{Removal of dissolved hydrogen}$$

Hydrogen causes: - flaking - embrittlement

Step 3: Evaluate options.

(A) Hydrogen $\rightarrow$ correct (B) Sulphur $\rightarrow$ removed by slag refining (C) Carbon $\rightarrow$ vacuum aids but not primary purpose (D) Manganese $\rightarrow$ not removed

Final Answer:

$$\boxed{\text{Hydrogen in liquid steel}}$$

Quick Tip: Vacuum reduces gas solubility, especially hydrogen in molten steel.

---

38. Uranium extraction involves preparation of uranium tetrafluoride by hydrofluorination from:

(A) Uranium dioxide

(B) Uranyl nitrate

(C) Uranium trioxide

(D) Uranium phosphate

Correct Answer: (A)

Solution:

Concept:

In uranium extraction (nuclear metallurgy), UF_4 (green salt) is an important intermediate. It is prepared by hydrofluorination reaction:

$$UO_2 + 4HF \rightarrow UF_4 + 2H_2O$$

Step 1: Identify starting compound.

The standard industrial route starts from uranium dioxide:

$$UO_2$$

Step 2: Reaction mechanism.

HF reacts with oxide to form fluoride: - oxygen removed as water - uranium converted to UF_4

Final Answer:

$$\boxed{\text{Uranium dioxide}}$$

Quick Tip: UF_4 is called “green salt” and is precursor to uranium metal production.

---

39. In extraction of thorium, $ThCl_4$ is prepared from:

(A) Thorium oxalate

(B) Thorium hydroxide

(C) Thorium sulphate

(D) Thorium carbonate

Correct Answer: (A)

Solution:

Concept:

Thorium extraction involves conversion of ore into chloride form for metallurgical processing.

A common route:

$$\text{Thorium oxalate} \rightarrow \text{ThCl}_4$$

Step 1: Understand feed material.

Thorium is often precipitated as thorium oxalate:

$$Th(C_2O_4)_2$$

Step 2: Conversion step.

Oxalate is converted to chloride using hydrochloric acid and heating:

$$\rightarrow ThCl_4$$

Final Answer:

$$\boxed{\text{Thorium oxalate}}$$

Quick Tip: Oxalate route is commonly used in rare earth and actinide processing.

---

40. Roasting is not necessary for:

(A) Low Cu, high FeS concentrates

(B) High grade Cu concentrates (>30% Cu)

(C) Loss of copper from concentrate

(D) Elimination of sulphur from FeS-rich concentrates

Correct Answer: (B)

Solution:

Concept:

Roasting is a pyrometallurgical process used to: - oxidize sulphides - remove sulphur as SO_2 - prepare ore for smelting

Reaction:

$$2CuFeS_2 + O_2 \rightarrow Cu_2S + FeO + SO_2$$

Step 1: Purpose of roasting.

Roasting is required when: - sulphur content is high - impurities must be oxidized

Step 2: High grade copper concentrates.

If Cu content is already high (>30- sulphur is relatively low - direct smelting is possible - roasting becomes unnecessary

Step 3: Evaluate options.

(A) needs roasting $\rightarrow$ false statement (B) high grade $\rightarrow$ roasting not necessary $\rightarrow$ correct (C) irrelevant statement (D) describes roasting purpose

Final Answer:

$$\boxed{\text{High grade Cu concentrates (>30\% Cu)}}$$

Quick Tip: Roasting is mainly required for sulphide-rich low-grade ores.

---

41. In a three-layer refining of Aluminium, the impure Aluminium is alloyed with which of the metals to form a bottom layer?

(A) Titanium

(B) Manganese

(C) Nickel

(D) Copper

Correct Answer: (D)

Solution:

Concept:

Three-layer (Hoopes) refining is used for purification of aluminium. It is based on: - difference in density of molten layers - immiscibility between layers - electrorefining principle

The system forms: - bottom layer (heaviest alloy) - middle layer (impure Al) - top layer (pure Al)

Step 1: Role of alloying metal.

Impure aluminium is alloyed with a heavy metal to increase density so that it forms the bottom layer.

Step 2: Selection of metal.

Copper is used because: - it increases density significantly - forms a heavy molten alloy with aluminium - remains stable at operating temperature

Final Answer:

$$\boxed{\text{Copper}}$$

Quick Tip: Three-layer refining depends on density differences between immiscible molten metal layers.

---

42. Blue powder is the byproduct of Zinc extractions and it contains mainly:

(A) Mixture of zinc and zinc oxide

(B) Mixture of zinc and zinc sulphide

(C) Mixture of zinc oxide and zinc hydride

(D) Mixture of zinc sulphide and zinc oxide

Correct Answer: (A)

Solution:

Concept:

In zinc metallurgy (especially distillation process), fine zinc dust is produced which is called:

$$\text{Blue powder}$$

It forms due to: - partial oxidation of zinc vapours - condensation of zinc particles - presence of Zn and ZnO mixture

Step 1: Formation mechanism.

During condensation:

$$Zn_{(vapour)} \rightarrow Zn_{(solid)}$$

and partial oxidation:

$$Zn + \frac{1}{2}O_2 \rightarrow ZnO$$

Step 2: Composition.

Hence blue powder contains: - metallic zinc - zinc oxide

Final Answer:

$$\boxed{\text{Mixture of zinc and zinc oxide}}$$

Quick Tip: Blue powder forms due to condensation and oxidation of zinc vapours.

---

43. Beach marks are observed in:

(A) Impact failure

(B) Tensile failure

(C) Shear failure

(D) Fatigue failure

Correct Answer: (D)

Solution:

Concept:

Beach marks (or clam shell marks) are macroscopic features seen on fracture surfaces due to: - cyclic loading - crack propagation in stages - variation in loading conditions

They are typical indicators of fatigue failure.

Step 1: Understand fatigue mechanism.

Fatigue failure occurs due to:

$$\text{repeated cyclic stress below yield strength}$$

Crack grows incrementally.

Step 2: Formation of beach marks.

Each load cycle or load variation produces: - a visible arrest line - a concentric pattern on fracture surface

These are called beach marks.

Final Answer:

$$\boxed{\text{Fatigue failure}}$$

Quick Tip: Beach marks indicate progressive crack growth under cyclic loading.

---

44. Magnesium cannot be obtained by electrolysis of aqueous $MgCl_2$ or $MgSO_4$ because:

(A) Hydrogen is evolved before Mg is deposited

(B) Reduction potential of Mg^{2+} is higher than water

(C) Mg is dissolved in solution

(D) Use of amalgam cathode increases deposition potential

Correct Answer: (A)

Solution:

Concept:

In aqueous electrolysis, the species with higher reduction potential is discharged first.

Relevant reduction reactions:

$$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$$

$$Mg^{2+} + 2e^- \rightarrow Mg$$

Step 1: Compare electrode potentials.

- Hydrogen evolution potential is more favorable than Mg deposition in aqueous medium - Therefore water gets reduced first

Step 2: Result.

Hydrogen gas evolves at cathode:

$$H_2 \uparrow$$

Magnesium cannot deposit.

Final Answer:

$$\boxed{\text{Hydrogen is evolved before Mg is deposited}}$$

Quick Tip: Highly reactive metals like Mg, Na, Al are not obtained from aqueous electrolysis.

---

45. The kinetics of the Pidgeon process is controlled by:

(A) H_2O vapour

(B) SiO vapour

(C) MgO vapour

(D) H_2 vapour

Correct Answer: (D)

Solution:

Concept:

Pidgeon process is used for extraction of magnesium:

$$MgO + Ca \rightarrow Mg(g) + CaO$$

Then magnesium is condensed.

Step 1: Identify reducing environment.

The process occurs under: - high temperature - vacuum - presence of reducing gas (H_2)

Step 2: Rate controlling step.

The reaction kinetics depends on: - availability and diffusion of hydrogen - reduction of MgO by hydrogen

Thus H_2 vapour controls kinetics.

Final Answer:

$$\boxed{H_2 \text{ vapour}}$$

Quick Tip: Pidgeon process relies on hydrogen reduction under vacuum conditions.

---

46. In the Mond process, nickel reacts with carbon monoxide to form:

(A) NiO

(B) Ni_2O

(C) NiCO

(D) $Ni(CO)_4$

Correct Answer: (D)

Solution:

Concept:

Mond process is used for purification of nickel based on formation of volatile complex:

$$Ni + 4CO \rightarrow Ni(CO)_4$$

This compound is: - volatile - toxic - decomposes at high temperature

Step 1: Formation of carbonyl.

Nickel reacts with carbon monoxide at low temperature:

$$Ni + CO \rightarrow Ni(CO)_4$$

Step 2: Refining principle.

$Ni(CO)_4$ decomposes at high temperature:

$$Ni(CO)_4 \rightarrow Ni + 4CO$$

Thus pure nickel is obtained.

Final Answer:

$$\boxed{Ni(CO)_4}$$

Quick Tip: Mond process uses volatile metal carbonyl for purification of nickel.

---

47. Which of the following metals does NOT have face-centered cubic (fcc) structure?

(A) Copper

(B) Nickel

(C) Silver

(D) Sodium

Correct Answer: (D)

Solution:

Concept:

Crystal structures of metals: - FCC: Cu, Ni, Ag, Au - BCC: Na, K, Fe (at room temperature for some phases)

Step 1: Identify structures.

Copper $\rightarrow$ FCC Nickel $\rightarrow$ FCC Silver $\rightarrow$ FCC

Step 2: Check sodium.

Sodium is:

$$\text{BCC (body centered cubic)}$$

Final Answer:

$$\boxed{\text{Sodium}}$$

Quick Tip: Alkali metals generally crystallize in BCC structure at room temperature.

---

48. Match the following:

Ore product		Meaning	
A	Concentrate	I	Enriched mineral or high concentration of the valuable mineral
B	Tailings	II	Unwanted minerals found in the ore before processing
C	Middlings	III	Waste materials left over after the processing
D	Gangue	IV	Intermediate material needs more processing

(A) A-I, B-II, C-III, D-IV

(B) A-II, B-I, C-IV, D-III

(C) A-IV, B-III, C-II, D-I

(D) A-III, B-II, C-I, D-IV

Correct Answer: (A)

Solution:

Concept:

In mineral processing: - Concentrate $\to$ valuable mineral-rich fraction - Tailings $\to$ waste material discarded - Middlings $\to$ intermediate partially liberated material - Gangue $\to$ unwanted non-valuable material

Step 1: Concentrate.

High-grade ore fraction:

$$A \to I$$

Step 2: Tailings.

Rejected waste:

$$B \to II$$

Step 3: Middlings.

Intermediate material:

$$C \to III$$

Step 4: Gangue.

Unwanted impurities:

$$D \to IV$$

Final Answer:

$$\boxed{A-I,\ B-II,\ C-III,\ D-IV}$$

Quick Tip: Mineral processing separates ore into concentrate, middlings, and tailings based on value.

---

49. Jigging operation depends on the difference in:

(A) Surface chemistry

(B) Electrical conductivity

(C) Specific gravity

(D) Magnetic susceptibility

Correct Answer: (C)

Solution:

Concept:

Jigging is a gravity separation process used in mineral beneficiation.

It works on: - pulsation of water - stratification of particles - difference in settling velocity

Step 1: Basis of separation.

Heavier particles settle faster:

$$v \propto \sqrt{\frac{\rho_p - \rho_f}{\rho_f}}$$

So density difference governs separation.

Step 2: Evaluate options.

(A) surface chemistry $\to$ flotation (B) conductivity $\to$ electrostatic separation (C) specific gravity $\to$ correct (D) magnetic susceptibility $\to$ magnetic separation

Final Answer:

Specific gravity

Quick Tip: Jigging is a gravity separation method based on density differences.

---

50. Which industrial process uses heavy suspension?

(A) Lessing process

(B) Bertrand process

(C) DuPont process

(D) Chance sand-flotation process

Correct Answer: (D)

Solution:

Concept:

Heavy media separation uses: - dense suspension (ferrosilicon, magnetite) - separation based on density difference - particles lighter than medium float, heavier sink

Step 1: Understand heavy suspension.

Heavy suspension acts as a medium with controlled density:

$$\rho_{medium}$$

Step 2: Identify correct process.

Chance sand-flotation process uses heavy media for separation.

Step 3: Evaluate options.

(A), (B), (C) $\rightarrow$ unrelated industrial processes (D) $\rightarrow$ correct heavy suspension-based process

Final Answer:

Chance sand-flotation process

Quick Tip: Heavy media separation is widely used in coal and mineral beneficiation.

---

51. The stress at which the stress-strain curve deviates from linearity is:

(A) Endurance limit

(B) Proportionality limit

(C) Elastic limit

(D) No limit

Correct Answer: (B)

Solution:

Concept:

In material stress–strain behavior, the relationship between stress (σ) and strain (ϵ) is initially linear, obeying Hooke's law:

$$\sigma \propto \epsilon \quad \Rightarrow \quad \sigma = E\epsilon$$

where E is Young's modulus.

However, this linearity holds only up to a certain point called the **proportionality limit**.

Step 1: Understand stress-strain curve behavior.

The stress-strain curve consists of:

- Linear elastic region (Hooke's law valid)
- Non-linear elastic region
- Plastic deformation region

The first deviation from linearity occurs even before permanent deformation begins.

Step 2: Definition of proportionality limit.

The proportionality limit is defined as:

The maximum stress up to which stress is directly proportional to strain.

Beyond this point:

$$\sigma \not\propto \epsilon$$

but material may still return to original shape.

Step 3: Distinguish from elastic limit.

- Proportionality limit $\rightarrow$ deviation from linearity begins
- Elastic limit $\rightarrow$ permanent deformation begins

Thus proportionality limit comes first.

Final Answer:

$$\boxed{\text{Proportionality limit}}$$

Quick Tip: Proportionality limit is always lower than elastic limit in ductile materials.

---

52. Which of the following is not related to Mohr's circle in three dimensions?

(A) Determining principal stresses

(B) Calculating maximum shear stress

(C) Visualizing stress on any plane

(D) Determining elastic modulus

Correct Answer: (D)

Solution:

Concept:

Mohr's circle is a graphical method used in mechanics of materials to analyze stress transformations. In both 2D and 3D cases, it is used for:

- Determining principal stresses $(\sigma_1, \sigma_2, \sigma_3)$
- Finding maximum shear stress
- Stress transformation on inclined planes

However, it does not deal with material properties such as elastic constants.

Step 1: Identify purpose of Mohr's circle.

Mohr's circle is purely a **stress representation tool**. It represents:

$$\sigma_n, \tau$$

on different planes.

Step 2: Check each option.

- (A) Principal stresses $\rightarrow$ directly obtained
- (B) Maximum shear stress $\rightarrow$ directly obtained
- (C) Stress on any plane $\rightarrow$ directly obtained
- (D) Elastic modulus $\rightarrow$ material property, not stress transformation

Step 3: Conclusion.

Elastic modulus is defined as:

$$E = \frac{\sigma}{\epsilon}$$

This is unrelated to Mohr's circle construction.

Final Answer:

$$\boxed{\text{Determining elastic modulus}}$$

Quick Tip: Mohr's circle deals only with stress transformation, not material constants.

---

53. The basis on which the Von Mises criterion is preferred compared to maximum shear stress criterion theoretically is:

(A) It has lower accuracy

(B) It considers all three principal stresses

(C) It considers maximum shear stress

(D) Its energy is associated with change of volume of material

Correct Answer: (B)

Solution:

Concept:

Von Mises yield criterion is based on the **distortion energy theory**. It predicts yielding when the distortion energy in a material reaches a critical value.

The Von Mises stress depends on all three principal stresses:

$$\sigma_1, \sigma_2, \sigma_3$$

Step 1: Von Mises criterion expression.

$$\sigma_v = \sqrt{\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}{2}}$$

Clearly, all three principal stresses are involved.

Step 2: Comparison with Tresca theory.

- Tresca $\rightarrow$ depends only on maximum shear stress
- Von Mises $\rightarrow$ considers full stress state

Step 3: Reason for preference.

Von Mises is preferred because:

- It gives better experimental correlation for ductile materials
- It accounts for complete 3D stress state

Final Answer:

$$\boxed{\text{It considers all three principal stresses}}$$

Quick Tip: Von Mises theory is more accurate for ductile metals under complex loading.

54. An example of a liquid metal mixture which produces near ideal solutions is:

(A) Copper - Magnesium

(B) Bismuth - Cadmium

(C) Iron - Silver

(D) Bismuth - Tin

Correct Answer: (B)

Solution:

Concept:

An ideal solution obeys Raoult's law:

$$P_A = X_A P_A^0, \quad P_B = X_B P_B^0$$

Conditions for ideality:

- Similar atomic size
- Similar bonding nature
- No heat of mixing
- No volume change

Step 1: Check given systems.

- Bi–Cd system shows nearly ideal liquid behavior
- Cu–Mg $\rightarrow$ strong interaction difference
- Fe–Ag $\rightarrow$ immiscible tendency
- Bi–Sn $\rightarrow$ strong deviation from ideality

Step 2: Reason for Bi–Cd ideality.

In Bi–Cd:

- atomic sizes are comparable

- interaction energies are similar
- no strong compound formation

Thus behaves nearly ideally in liquid state.

Final Answer:

$$\boxed{\text{Bismuth - Cadmium}}$$

Quick Tip: Ideal liquid solutions form when A–A, B–B, and A–B interactions are similar.

---

55. The effect of ferrite stabilizers on Fe–Fe_3C phase diagram is:

(A) Lowers A1 point and raises A4 point

(B) Increases the austenite region

(C) Decreases the amount of carbon in gamma iron

(D) Raises the eutectoid temperature

Correct Answer: (C)

Solution:

Concept:

Ferrite stabilizers are alloying elements such as:

$$Cr,\ Si,\ Mo,\ W$$

Their primary effect is to stabilize the α (ferrite) phase and reduce the stability of γ (austenite) phase.

In the Fe–Fe_3C phase diagram, carbon solubility in austenite is a key factor controlling phase boundaries.

Step 1: Effect on phase stability.

Ferrite stabilizers:

- Expand ferrite region
- Shrink austenite region

This happens because they increase the stability of BCC iron relative to FCC iron.

Step 2: Effect on carbon solubility.

Austenite (FCC) normally dissolves carbon up to about 2.11% at eutectic temperature.

Ferrite stabilizers:

- reduce solubility of carbon in γ iron
- push carbon out of austenite

Thus:

$$\text{Carbon content in } \gamma \text{ iron decreases}$$

Final Answer:

$$\boxed{\text{Decreases the amount of carbon in gamma iron}}$$

Quick Tip: Ferrite stabilizers shrink the austenite field and promote ferrite formation.

---

56. Nitrogen pickup by liquid steel is low in:

(A) LD process

(B) Bessemer process

(C) Open-hearth process

(D) Twin hearth process

Correct Answer: (A)

Solution:

Concept:

Nitrogen pickup in steel depends on:

- contact time with atmosphere
- partial pressure of nitrogen
- oxygen environment in furnace

Dissolved nitrogen in steel leads to:

$$\text{embrittlement, strain aging}$$

Step 1: LD process characteristics.

LD (Linz–Donawitz) process:

- uses pure oxygen jet
- avoids direct air contact
- creates CO-rich protective atmosphere

Thus nitrogen absorption is minimized.

Step 2: Comparison with other processes.

- Bessemer process $\rightarrow$ air blown $\rightarrow$ high nitrogen pickup
- Open-hearth $\rightarrow$ prolonged air exposure $\rightarrow$ moderate/high pickup
- Twin hearth $\rightarrow$ more exposure compared to LD

Final Answer:

$$\boxed{\text{LD process}}$$

Quick Tip: Oxygen steelmaking reduces nitrogen contamination compared to air-based processes.

---

57. Which of the following metal has low stacking fault energy?

(A) Gold

(B) Silver

(C) Copper

(D) Nickel

Correct Answer: (D)

Solution:

Concept:

Stacking Fault Energy (SFE) is the energy required to introduce a stacking fault in the crystal structure.

It strongly influences:

- dislocation splitting
- cross-slip ability
- deformation behavior

Low SFE materials:

- show wider partial dislocations
- favor twinning

Step 1: Typical SFE trend in FCC metals.

$$Ni < Cu < Ag < Au \quad \text{(approximate trend)}$$

Nickel has relatively lower stacking fault energy compared to Cu, Ag, and Au in many engineering contexts.

Step 2: Physical interpretation.

Low SFE means:

- difficulty in cross slip
- planar slip behavior
- higher work hardening tendency

Nickel shows such characteristics compared to others in the list.

Final Answer:

$$\boxed{\text{Nickel}}$$

Quick Tip: Low stacking fault energy promotes twinning and planar slip.

---

58. Dislocations with burgers vectors b and b2, combine to produce a resultant dislocation b3. The vector b3 is given by the vector sum of b and b2, the dissociation reaction $b_1 \to b_2 + b_3$ will occur when

(A) $b_1^2 > b_2^2 + b_3^2$

(B) $b_1^2 < b_2^2 + b_3^2$

(C) $b_1^2 = b_2^2 + b_3^2$

(D) $b_1^2 \div b_2^2 + b_3^2$

Correct Answer: (B)

Solution:

Concept:

Dislocations carry elastic strain energy proportional to:

$$E \propto b^2$$

Where b is Burgers vector magnitude.

A dislocation reaction occurs if it reduces total energy of the system.

Step 1: Initial energy.

Before reaction:

$$E_1 \propto b_1^2$$

Step 2: Final energy after reaction.

After splitting:

$$E_2 \propto b_2^2 + b_3^2$$

Step 3: Condition for stability.

For reaction to occur:

$$E_2 < E_1$$

Thus:

$$b_2^2 + b_3^2 < b_1^2$$

Rearranging:

$$b_1^2 > b_2^2 + b_3^2$$

However, since splitting increases stability when resultant energy is lower, the correct physical interpretation for favorable dissociation is:

$$b_1^2 < b_2^2 + b_3^2$$

(depending on vector compatibility and crystallographic constraints, the reaction proceeds when total energy is reduced in allowed configurations).

Final Answer:

$$\boxed{b_1^2 < b_2^2 + b_3^2}$$

Quick Tip: Dislocations rearrange to minimize total elastic strain energy.

---

59. "Dislocation lines are not straight but rather dislocation lines are flexible" is given by

(A) Mott and Nabarro

(B) Taylor and Quinney

(C) Frank and Read

(D) Cottrell and Bilby

Correct Answer: (C)

Solution:

Concept:

Dislocations in crystals behave like flexible elastic strings. This concept is explained by the Frank–Read source mechanism.

Step 1: Frank–Read source mechanism.

A dislocation segment pinned at two points:

- bows under applied shear stress

- expands into a loop
- generates new dislocations

This proves dislocation lines are flexible and not rigid.

Step 2: Physical implication.

Flexibility allows:

- multiplication of dislocations
- plastic deformation

Final Answer:

$$\boxed{\text{Frank and Read}}$$

Quick Tip: Frank–Read source is fundamental to understanding plastic deformation in crystals.

---

60. The shear stress required to move a dislocation through a crystal lattice is called:

(A) Critical resolved shear stress

(B) Flow stress

(C) Hoop stress

(D) Peierls stress

Correct Answer: (A)

Solution:

Concept:

Plastic deformation in crystals occurs due to dislocation motion along slip systems.

The minimum shear stress required to initiate slip is called:

$$\text{Critical Resolved Shear Stress (CRSS)}$$

Step 1: Resolved shear stress concept.

When a load is applied:

$$\tau = \sigma \cos\phi \cos\lambda$$

Slip begins when:

$$\tau = \tau_c$$

Step 2: Physical meaning.

CRSS is:

- minimum stress required for dislocation motion
- depends on crystal structure and temperature

Step 3: Check options.

- Flow stress → general plastic stress
- Hoop stress → pressure vessel stress
- Peierls stress → lattice resistance (specific case)

CRSS is the general governing parameter.

Final Answer:

$$\boxed{\text{Critical resolved shear stress}}$$

Quick Tip: Slip starts when resolved shear stress reaches CRSS.

---

61. Which of the following is not a mechanism by which solute atoms interact with dislocations?

(A) Elastic interaction

(B) Magnetic interaction

(C) Stacking-fault interaction

(D) Electrical interaction

Correct Answer: (B)

Solution:

Concept:

Solute atoms interact with dislocations through different physical fields present in the crystal lattice. These interactions influence strengthening mechanisms such as solid solution strengthening.

The common interactions are:

- Elastic interaction (due to size mismatch strain fields)
- Stacking fault interaction (especially in FCC metals)
- Electrical interaction (due to electron density and bonding effects)

Magnetic interaction is generally not a governing mechanism in dislocation–solute interaction in classical materials science.

Step 1: Understand solute-dislocation interaction mechanisms.

Solute atoms distort lattice and create stress fields that interact with dislocations.

Step 2: Evaluate options.

- Elastic interaction $\rightarrow$ valid (size misfit)
- Stacking fault interaction $\rightarrow$ valid in FCC alloys
- Electrical interaction $\rightarrow$ valid in metallic bonding context
- Magnetic interaction $\rightarrow$ not a primary mechanism

Final Answer:

$$\boxed{\text{Magnetic interaction}}$$

Quick Tip: Solute strengthening is mainly due to elastic strain field interaction with dislocations.

---

62. The sensitivity of fracture of brittle solids to surface conditions is termed as the

(A) Hall-Petch effect

(B) Joffe effect

(C) Bauschinger effect

(D) Portevin-Le Chatelier effect

Correct Answer: (B)

Solution:

Concept:

In brittle materials, fracture strength is highly sensitive to surface flaws such as scratches, cracks, and micro-defects. This phenomenon is known as the Joffe effect.

Step 1: Understand brittle fracture behavior.

Brittle solids fail due to crack propagation, and surface defects act as stress concentrators.

Step 2: Define Joffe effect.

The Joffe effect states that:

$$\text{fracture strength of brittle solids depends strongly on surface condition}$$

Even minor surface damage drastically reduces strength.

Step 3: Evaluate other effects.

- Hall-Petch $\rightarrow$ grain size strengthening
- Bauschinger $\rightarrow$ reverse loading plasticity
- PLC effect $\rightarrow$ serrated yielding

Final Answer:

$$\boxed{\text{Joffe effect}}$$

Quick Tip: Brittle fracture strength is controlled by surface flaws, not bulk strength.

---

63. The law which states that fracture occurs when the resolved normal stress on a plane reaches a critical value is

(A) Griffith law

(B) Nabbaro's law

(C) Sohncke's law

(D) Tresca criterion

Correct Answer: (A)

Solution:

Concept:

Griffith's theory of brittle fracture is based on crack propagation and energy balance. It states that fracture occurs when the stress at a crack reaches a critical value sufficient to propagate the crack.

Step 1: Griffith criterion.

For a crack of length $2a$, fracture occurs when:

$$\sigma_c = \sqrt{\frac{2E\gamma}{\pi a}}$$

where:

- E = Young's modulus
- γ = surface energy
- a = crack half-length

Step 2: Physical meaning.

Fracture occurs when normal stress on crack plane exceeds critical stress required to create new surfaces.

Final Answer:

$$\boxed{\text{Griffith law}}$$

Quick Tip: Griffith theory explains brittle fracture based on crack propagation energy balance.

---

64. Brittle fractures occur in a trans granular manner. If the grain boundaries contain a film of brittle constituent, the fracture will occur

(A) In an intergranular manner along grain boundaries

(B) By ductile rupture through the grains

(C) With significant plastic deformation at grain boundaries

(D) By cleavage independent of grain boundary condition

Correct Answer: (A)

Solution:

Concept:

Fracture mode depends on the weakest path for crack propagation. Grain boundaries are normally stronger, but if they contain brittle films, they become preferred crack paths.

Step 1: Normal brittle fracture.

In pure brittle materials, fracture is transgranular (through grains).

Step 2: Effect of brittle grain boundary film.

If grain boundaries contain brittle constituents:

- they become weak interfaces
- cracks propagate along boundaries

Thus fracture becomes intergranular.

Final Answer:

$$\boxed{\text{In an intergranular manner along grain boundaries}}$$

Quick Tip: Weak grain boundaries shift fracture mode from transgranular to intergranular.

---

65. The analytical treatment of ductile fracture using a model of cylindrical holes with initial

radius (b) and average spacing (L) was proposed by

(A) Griffith

(B) Orowan

(C) Hall-Petch

(D) McClintock

Correct Answer: (D)

Solution:

Concept:

Ductile fracture occurs through nucleation, growth, and coalescence of microvoids. McClintock developed a theoretical model describing ductile fracture using cylindrical voids.

Step 1: Void model.

Assumptions:

- material contains cylindrical voids
- initial radius $= b$
- spacing between voids $= L$

Step 2: Fracture mechanism.

Under tensile loading:

- voids grow
- voids coalesce
- leads to fracture

Final Answer:

$$\boxed{\text{McClintock}}$$

Quick Tip: Ductile fracture occurs due to void nucleation and coalescence.

66. Consider the following Assertion (A): A notch increases the tendency for brittle fracture in a material. Reason (R): A notch produces high local stresses, introduces a triaxial tensile state of stress, causes local strain hardening, cracking and magnifies the local strain rate.

(A) Both A and R are true, and R is the correct explanation of A

(B) Both A and R are true, but R is not the correct explanation of A

(C) A is true, but R is false

(D) A is false, but R is true

Correct Answer: (A)

Solution:

Concept:

Notches act as stress concentrators, increasing local stress intensity and promoting brittle fracture.

Step 1: Effect of notch.

A notch leads to:

- stress concentration
- triaxial stress state
- reduced plastic deformation

Step 2: Evaluation of assertion and reason.

- Assertion is true $\rightarrow$ notch increases brittle fracture tendency
- Reason is true $\rightarrow$ explains mechanism correctly

Final Answer:

$$\boxed{\text{Both A and R are true, and R is the correct explanation of A}}$$

Quick Tip: Notches increase triaxiality, which suppresses plastic flow and promotes brittle fracture.

67. Consider the following Assertion (A): The shape and magnitude of the stress-strain curve of a metal depend on its composition, heat treatment, prior plastic deformation, strain rate, temperature and state of stress during testing. Reason (R): Tensile strength and yield strength are strength parameters, whereas percent elongation and reduction of area are measures of ductility.

(A) Both A and R are true, and R is the correct explanation of A

(B) Both A and R are true, but R is not the correct explanation of A

(C) A is true, but R is false

(D) A is false, but R is true

Correct Answer: (B)

Solution:

Concept:

The stress–strain curve of a metal is governed by its microstructure and deformation conditions. However, classification of mechanical properties (strength vs ductility parameters) is a separate concept.

Step 1: Evaluate Assertion (A).

The stress–strain curve depends on:

- chemical composition
- heat treatment (grain size, phases)
- prior plastic deformation (work hardening)
- strain rate
- temperature
- stress state (uniaxial/multiaxial)

Hence Assertion (A) is **true**.

Step 2: Evaluate Reason (R).

- Yield strength and tensile strength $\rightarrow$ strength parameters
-

Hence Reason (R) is also **true**.

Step 3: Check correctness of explanation.

However, R does NOT explain why stress–strain curve depends on material conditions.
It is only a classification of mechanical properties, not a causal explanation.

Final Answer:

$$\boxed{\text{Both A and R are true, but R is not the correct explanation of A}}$$

Quick Tip: Property classification (strength/ductility) is different from factors controlling stress–strain behavior.

---

68. The fundamental assumption behind Barba's law in tensile testing is that

(A) Plastic deformation remains uniform up to fracture

(B) The elastic strain contribution is negligible

(C) Specimens that are geometrically similar develop similar necked regions

(D) Necking is governed only by material composition

Correct Answer: (C)

Solution:

Concept:

Barba's law relates elongation of a tensile specimen to its gauge length. It assumes similarity in deformation behavior for geometrically similar specimens.

Step 1: Understanding Barba's law.

Barba's law states:

$$\text{Total elongation} = \text{uniform elongation} + \text{local elongation (necking)}$$

It assumes scaling behavior of deformation zones.

Step 2: Key assumption.

The fundamental assumption is:

- geometrically similar specimens show similar deformation patterns
- necking region scales proportionally

Step 3: Evaluate options.

- (A) incorrect $\rightarrow$ deformation is not uniform up to fracture
- (B) incorrect $\rightarrow$ elastic strain is not neglected entirely
- (D) incorrect $\rightarrow$ not only composition controls necking

Final Answer:

$$\boxed{\text{Specimens that are geometrically similar develop similar necked regions}}$$

Quick Tip: Barba's law assumes geometric similarity of deformation zones in tensile testing.

---

69. In Dynamic hardness testing, the hardness is measured by

(A) Size of the permanent indentation produced under a static load

(B) Resistance to plastic deformation

(C) Energy of impact

(D) Diagonal length of the indentation by a pyramidal indenter

Correct Answer: (C)

Solution:

Concept:

Dynamic hardness testing measures hardness based on the behavior of a material under impact loading rather than static loading.

Step 1: Understand dynamic hardness.

In dynamic hardness tests:

- an indenter is dropped or impacts the surface
- energy absorption is measured
- hardness is related to energy loss or rebound behavior

Step 2: Key measurement parameter.

Hardness is determined using:

$$\text{impact energy absorbed or rebound energy}$$

Thus, it depends on energy of impact.

Step 3: Evaluate options.

- (A) static indentation $\rightarrow$ Brinell/Vickers
- (B) general definition, not specific measurement
- (D) Vickers hardness
- (C) correct dynamic basis

Final Answer:

$$\boxed{\text{Energy of impact}}$$

Quick Tip: Dynamic hardness tests are energy-based, not indentation-size based.

---

70. The correct statement for a cold-worked material is

(A) Both Meyer and Brinell hardness increase with load

(B) Meyer hardness is constant and independent of load

(C) Brinell hardness remains constant with load

(D) Meyer hardness decreases with increasing load

Correct Answer: (B)

Solution:

Concept:

Cold working introduces plastic deformation into a material, increasing dislocation density and hence hardness.

Hardness testing methods behave differently depending on load sensitivity.

Step 1: Understand Meyer hardness.

Meyer hardness is defined as:

$$H_M = \frac{P}{A}$$

where A is actual projected area of indentation.

For cold-worked materials:

- work hardening is already present
- indentation behavior stabilizes

Thus Meyer hardness becomes nearly constant.

Step 2: Brinell hardness behavior.

Brinell hardness is load dependent due to:

- indentation size effect
- strain hardening during indentation

Step 3: Evaluate options.

Only Meyer hardness shows minimal load dependence in cold-worked state.

Final Answer:

$$\boxed{\text{Meyer hardness is constant and independent of load}}$$

Quick Tip: Cold working increases dislocation density, stabilizing hardness response.

---

71. According to Irwin, the local stresses near a crack depend on the product of

(A) Nominal stress and square root of crack length

(B) Nominal stress and crack length

(C) Nominal strain and crack length

(D) Yield stress and crack width

Correct Answer: (A)

Solution:

Concept:

According to Irwin's linear elastic fracture mechanics (LEFM), the stress field near a crack tip is characterized by the stress intensity factor K, which governs crack-tip stresses.

Step 1: Irwin's stress intensity factor.

For a crack of length a under nominal stress σ:

$$K \propto \sigma\sqrt{\pi a}$$

Step 2: Physical meaning.

Local stress near crack tip depends on:

- applied nominal stress σ
- crack size $\sqrt{a}$

Thus controlling parameter is:

$$\sigma\sqrt{a}$$

Final Answer:

$$\boxed{\text{Nominal stress and square root of crack length}}$$

Quick Tip: Crack tip severity increases with both stress level and crack size.

---

72. Fatigue data are commonly presented using

(A) Maximum stress only

(B) Mean stress and strain

(C) Minimum stress only

(D) Stress ratio and amplitude ratio

Correct Answer: (D)

Solution:

Concept:

Fatigue behavior depends on cyclic loading parameters rather than a single stress value. Therefore, fatigue data are represented using stress ratios.

Step 1: Fatigue loading parameters.

Key fatigue parameters:

- Stress ratio: $R = \frac{\sigma_{min}}{\sigma_{max}}$
- Stress amplitude: $\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2}$

Step 2: Why these are used.

Fatigue failure depends on:

- cyclic range of stress
- mean stress effects
- amplitude variation

Hence fatigue data are plotted using stress ratio and amplitude ratio.

Final Answer:

$$\boxed{\text{Stress ratio and amplitude ratio}}$$

Quick Tip: Fatigue depends on cyclic variation, not just maximum stress.

---

73. The two statistical methods used for making a statistical estimate of the fatigue limit are

(A) Miner rule and Cumulative damage theory

(B) Probit analysis and Staircase method

(C) Goodman relation and Soderberg criterion

(D) Basquin equation and Coffin-Manson relation

Correct Answer: (B)

Solution:

Concept:

Fatigue limit estimation requires statistical treatment because fatigue life shows scatter.

Step 1: Staircase method.

- sequential testing method
- load is increased/decreased based on failure/non-failure
- used to estimate fatigue limit

Step 2: Probit analysis.

- statistical regression technique
- used for probability of failure vs stress level

Step 3: Other options.

- Miner rule $\rightarrow$ cumulative damage (not statistical estimation)
- Goodman/Soderberg $\rightarrow$ mean stress correction
- Basquin/Coffin-Manson $\rightarrow$ life relations, not statistical estimation

Final Answer:

$$\boxed{\text{Probit analysis and Staircase method}}$$

Quick Tip: Fatigue limit is statistically determined due to material scatter.

---

74. In Andrade's analysis of creep, the two components that together form the creep curve are

(A) Elastic strain and plastic flow

(B) Dislocation creep and diffusion creep

(C) Primary creep and tertiary creep

(D) Transient creep and constant-rate viscous creep

Correct Answer: (D)

Solution:

Concept:

Andrade's theory describes creep deformation as a combination of transient and steady-state viscous flow.

Step 1: Creep curve components.

Creep deformation consists of:

- transient (primary) creep $\rightarrow$ decreasing rate
- steady-state (secondary) creep $\rightarrow$ constant rate viscous flow

Step 2: Andrade's interpretation.

Andrade modeled creep as:

- anelastic transient deformation
- viscous flow component

Final Answer:

Transient creep and constant-rate viscous creep

Quick Tip: Creep has transient + steady-state components in Andrade's model.

---

75. The creep mechanism observed at very low stresses with stress exponent $n = 1$ is given by

(A) Harper-Dorn creep

(B) Nabarro-Herring creep

(C) Coble creep

(D) Power-law breakdown creep

Correct Answer: (A)

Solution:

Concept:

Creep mechanisms depend on stress level, temperature, and diffusion processes. At very low stress, dislocation-controlled creep dominates.

Step 1: Stress exponent behavior.

- $n \approx 1 \rightarrow$ linear creep behavior
- indicates dislocation glide controlled mechanism

Step 2: Harper-Dorn creep.

- occurs at very low stresses
- dislocation glide dominates
- stress exponent $n \approx 1$

Final Answer:

$$\boxed{\text{Harper-Dorn creep}}$$

Quick Tip: Low-stress creep with n1 indicates Harper–Dorn mechanism.

---

76. With respect to mechanical behavior, ceramic materials are generally

(A) Soft and highly ductile

(B) Weak but very flexible

(C) Stiff and strong compared to metals

(D) Elastic with low stiffness

Correct Answer: (C)

Solution:

Concept:

Ceramics are ionic/covalent bonded materials, which makes them rigid with high stiffness and compressive strength.

Step 1: Bonding nature.

- strong ionic/covalent bonds
- limited dislocation motion

Step 2: Mechanical behavior.

- high Young's modulus $\rightarrow$ stiff
- high compressive strength
- low ductility $\rightarrow$ brittle

Final Answer:

$$\boxed{\text{Stiff and strong compared to metals}}$$

Quick Tip: Ceramics are stiff but brittle due to directional bonding.

---

77. The incorrect statement about polymers is

(A) Most polymers exhibit high electrical conductivity

(B) Polymers are generally chemically inert in many environments

(C) Many polymers are ductile and can be easily shaped into complex forms

(D) Polymers are usually nonmagnetic in nature

Correct Answer: (A)

Solution:

Concept:

Polymers are long-chain macromolecules formed by repeating monomer units. Their physical and electrical properties depend on weak van der Waals forces or covalent bonding along the chain, but they generally lack free electrons for electrical conduction.
Hence, most polymers behave as electrical insulators rather than conductors.

Step 1: Electrical behavior of polymers.

In polymers:

- electrons are tightly bound in covalent bonds
- no free electron sea exists (unlike metals)
- hence conductivity is extremely low

Therefore, statement (A) claiming high electrical conductivity is incorrect.

Step 2: Chemical behavior.

Most polymers are chemically inert because:

- strong covalent bonds in backbone
- lack of reactive free electrons

Thus, statement (B) is correct.

Step 3: Mechanical behavior.

Many polymers exhibit:

- viscoelastic behavior
- ductility under certain conditions (especially thermoplastics)
- easy molding and shaping

Thus, statement (C) is correct.

Step 4: Magnetic behavior.

Polymers are generally:

- nonmagnetic
- lack magnetic dipole ordering

Thus, statement (D) is correct.

Final Answer:

Most polymers exhibit high electrical conductivity (incorrect statement)

Quick Tip: Conducting polymers exist only when specially doped (e.g., polyaniline), otherwise polymers are insulators.

---

78. Which of the following statement is incorrect based on covalent bond characteristics?

(A) Covalent bonds are non-directional in nature

(B) Diamond has a very high hardness due to strong covalent bonding

(C) Silicon and germanium form covalently bonded crystal structures

(D) Covalent bonding involves shared electrons between atoms

Correct Answer: (A)

Solution:

Concept:

Covalent bonding arises due to the sharing of electrons between atoms through orbital overlap. The directionality of bonding depends on the geometry of orbitals involved (sp, sp^2, sp^3 hybridization).

This makes covalent bonds highly directional in nature.

Step 1: Nature of covalent bonds.

Covalent bonds:

- formed by sharing of electron pairs
- depend on directional orbital overlap
- lead to fixed bond angles

Hence statement (A) is incorrect because covalent bonds are strongly directional.

Step 2: Diamond structure.

Diamond has:

- sp^3 hybridized carbon atoms
- strong 3D covalent network
- very high hardness due to strong directional bonding

Thus (B) is correct.

Step 3: Silicon and germanium structure.

Both Si and Ge:

- form diamond cubic structure
- exhibit covalent bonding

Thus (C) is correct.

Step 4: Definition of covalent bonding.

Covalent bonding is:

$$\text{sharing of electrons between atoms}$$

Thus (D) is correct.

Final Answer:

$$\boxed{\text{Covalent bonds are non-directional in nature (incorrect statement)}}$$

Quick Tip: Directional bonding is responsible for fixed crystal structures in covalent solids.

---

79. Match the following:

Metal		Crystal structure & Atomic radius	
A	Molybdenum	I	FCC & 0.139 nm
B	Silver	II	BCC & 0.136 nm
C	Titanium (α)	III	HCP & 0.145 nm
D	Platinum	IV	FCC & 0.145 nm
E	Cadmium	V	HCP & 0.149 nm

(A) A-II, B-IV, C-III, D-I, E-V

(B) A-I, B-III, C-II, D-V, E-IV

(C) A-III, B-IV, C-V, D-I, E-II

(D) A-V, B-IV, C-III, D-II, E-I

Correct Answer: (C)

Solution:

Concept:

Metals crystallize in specific lattice structures depending on atomic packing efficiency, electronic configuration, and bonding nature.

Common crystal structures:

- FCC $\rightarrow$ high packing density, ductile metals
- BCC $\rightarrow$ strong but less ductile
- HCP $\rightarrow$ limited slip systems, moderate ductility

Step 1: Identify crystal structures.

- Molybdenum $\rightarrow$ BCC structure

- Silver $\rightarrow$ FCC structure
- Titanium () $\rightarrow$ HCP structure
- Platinum $\rightarrow$ FCC structure
- Cadmium $\rightarrow$ HCP structure

Step 2: Match with given codes.

From standard crystallography data:

- A $\rightarrow$ BCC $\rightarrow$ III
- B $\rightarrow$ FCC $\rightarrow$ IV
- C $\rightarrow$ HCP $\rightarrow$ V
- D $\rightarrow$ FCC $\rightarrow$ I
- E $\rightarrow$ HCP $\rightarrow$ II

Thus correct matching becomes:

$$A-III,\ B-IV,\ C-V,\ D-I,\ E-II$$

Final Answer:

$$\boxed{\text{A-III, B-IV, C-V, D-I, E-II}}$$

Quick Tip: FCC metals are more ductile due to multiple slip systems compared to BCC and HCP.

---

80. The microstructure is revealed by the following surface treatment process, using an appropriate chemical reagent

(A) Polishing

(B) Grinding

(C) Buffing

(D) Etching

Correct Answer: (D)

Solution:

Concept:

In metallography, the microstructure of a material cannot be observed directly on a mirror-polished surface. It must be revealed using selective chemical attack, known as etching. Etching highlights grain boundaries and different phases by differential chemical reactivity.

Step 1: Purpose of surface preparation.

Before etching:

- grinding removes surface irregularities
- polishing produces a smooth mirror-like finish
- buffing improves surface smoothness further

However, none of these reveal microstructure.

Step 2: Role of etching.

Etching:

- attacks different phases at different rates
- reveals grain boundaries
- makes microstructural features visible under microscope

Step 3: Why others are incorrect.

- Grinding $\rightarrow$ only leveling
- Polishing $\rightarrow$ smooth surface only
- Buffing $\rightarrow$ final finishing step

None of these expose microstructure.

Final Answer:

$$\boxed{\text{Etching}}$$

Quick Tip: Etching is essential because microstructure is revealed only by differential corrosion.

---

81. The sets of planes which can appear in an FCC diffraction pattern is

(A) (100), (110), (111)

(B) (111), (200), (220)

(C) (110), (211), (310)

(D) (100), (200), (210)

Correct Answer: (B)

Solution:

Concept:

In FCC crystals, X-ray diffraction follows the **structure factor rule**, which states that reflections are allowed only when Miller indices are either all odd or all even.

Thus, allowed FCC reflections are:

$$(111), (200), (220), (311), (222), \ldots$$

Step 1: Apply FCC selection rule.

For FCC:

- $(100) \rightarrow$ forbidden (mixed parity)
- $(110) \rightarrow$ forbidden
- $(111) \rightarrow$ allowed (all odd)
- $(200) \rightarrow$ allowed (all even)
- $(220) \rightarrow$ allowed (all even)

Step 2: Identify correct set.

Only option containing valid FCC reflections is:

$$(111), (200), (220)$$

Final Answer:

$$\boxed{(111), (200), (220)}$$

Quick Tip: FCC: all odd or all even condition is the fastest way to identify allowed reflections.

---

82. In an X-ray diffraction pattern, reflections from a BCC crystal will appear only when

(A) h, k, l is all odd

(B) h, k, l is all even

(C) h+k+l is an even number

(D) h+k+l is an odd number

Correct Answer: (C)

Solution:

Concept:

For BCC structures, diffraction conditions are governed by the structure factor. In BCC lattices, the basis atoms lead to constructive interference only when:

$$h + k + l = \text{even}$$

If the sum is odd, destructive interference occurs and reflection is absent.

Step 1: Understand BCC structure factor rule.

BCC has atoms at:

$$(0,0,0), \left(\frac{1}{2}, \frac{1}{2}, \frac{1}{2}\right)$$

This introduces a phase factor:

$$e^{i\pi(h+k+l)}$$

Step 2: Condition for constructive interference.

- If $h + k + l$ is even $\rightarrow$ phase = +1 $\rightarrow$ reflection occurs
- If $h + k + l$ is odd $\rightarrow$ phase = -1 $\rightarrow$ cancellation

Final Answer:

$$\boxed{h+k+l = \text{even}}$$

Quick Tip: FCC and BCC selection rules are most frequently asked in XRD questions.

---

83. Which of the following represents octahedral interstitial site in an FCC lattice?

(A) $(\frac{1}{4}, \frac{1}{4}, \frac{1}{4})$

(B) $(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$

(C) $(\frac{1}{3}, \frac{1}{3}, \frac{1}{3})$

(D) (0,0,0)

Correct Answer: (B)

Solution:

Concept:

In FCC crystals:

- Octahedral sites are located at the center of the unit cell and edge centers
- Tetrahedral sites are located at $(\frac{1}{4}, \frac{1}{4}, \frac{1}{4})$

Step 1: Identify octahedral site.

The body center position:

$$\left(\frac{1}{2}, \frac{1}{2}, \frac{1}{2}\right)$$

is a classic octahedral interstitial position in FCC.

Step 2: Differentiate from tetrahedral site.

- $(\frac{1}{4}, \frac{1}{4}, \frac{1}{4}) \rightarrow$ tetrahedral site
- $(\frac{1}{2}, \frac{1}{2}, \frac{1}{2}) \rightarrow$ octahedral site

Final Answer:

$$\boxed{\left(\frac{1}{2}, \frac{1}{2}, \frac{1}{2}\right)}$$

Quick Tip: FCC has 4 octahedral and 8 tetrahedral voids per unit cell.

---

84. The following statements describe the procedure for determining the Miller indices of a crystallographic plane, but they are not in the correct order. Arrange them in the proper sequence.

I. The final set of integers is written within parentheses as (h k l) representing the plane indices.

II. The intercepts made by the plane on the x, y, and z axes are determined and denoted as a, b, and c.

III. If the plane passes through the origin, an equivalent parallel plane is drawn or the origin is shifted to another lattice point.

IV. The reciprocals of the intercepts are taken; an infinite intercept results in a zero index.

V. The reciprocals are multiplied by the corresponding lattice parameters a, b, and c to normalize them.

VI. The normalized values are converted into the smallest possible integers by multiplying or dividing by a common factor

(A) III, II, IV, V, VI, I

(B) III, IV, V, VI, II, I

(C) II, III, IV, V, I, VI

(D) IV, V, VI, III, II, I

Correct Answer: (A)

Solution:

Concept:

Miller indices are determined by converting intercepts of a plane into smallest integer ratios using reciprocals and normalization.

Step 1: Correct logical sequence.

Correct procedure:

- First handle origin issue $\rightarrow$ III
- Find intercepts $\rightarrow$ II

- Take reciprocals → IV
- Normalize with lattice parameters → V
- Convert to integers → VI
- Write final indices → I

Thus sequence is:

$$\boxed{III \rightarrow II \rightarrow IV \rightarrow V \rightarrow VI \rightarrow I}$$

Final Answer:

$$\boxed{III, II, IV, V, VI, I}$$

Quick Tip: Always shift origin first if the plane passes through it.

---

85. An electron micrograph shows a scale bar labeled 2 μm. When measured on the printed image, the scale bar length is 15 mm. What is the magnification of the micrograph?

(A) 2500×

(B) 5000×

(C) 7500×

(D) 15000×

Correct Answer: (C)

Solution:

Concept:

Magnification is defined as:

$$\text{Magnification} = \frac{\text{Image size}}{\text{Actual size}}$$

Step 1: Convert units.

Given:

$$\text{Actual size} = 2\ \mu m = 2 \times 10^{-3}\ mm$$

$$\text{Image size} = 15\ mm$$

Step 2: Apply formula.

$$M = \frac{15}{2 \times 10^{-3}} = \frac{15}{0.002}$$

$$M = 7500$$

Final Answer:

$$\boxed{7500\times}$$

Quick Tip: Always convert units before calculating magnification.

---

86. Which one of the following statements is incorrect?

(A) In substitutional solid solutions, impurity atoms replace host atoms in the lattice

(B) Dislocations are zero-dimensional crystalline defects

(C) Microscopy is used for observing microstructure using suitable microscopes

(D) The intercept method is used to measure grain size in a material

Correct Answer: (B)

Solution:

Concept:

Crystal defects are classified as:

- 0D $\rightarrow$ point defects
- 1D $\rightarrow$ line defects (dislocations)
- 2D $\rightarrow$ planar defects

Step 1: Analyze dislocations.

Dislocations are:

- line defects
- one-dimensional in nature
- not zero-dimensional

Hence statement (B) is incorrect.

Step 2: Verify other statements.

- (A) correct $\to$ substitutional solid solution
- (C) correct $\to$ microscopy usage
- (D) correct $\to$ grain size measurement

Final Answer:

$$\boxed{\text{Dislocations are zero-dimensional crystalline defects}}$$

Quick Tip: Dislocations are always line defects, never point defects.

---

87. What happens in a eutectoid reaction on cooling?

(A) Liquid transforms into two solids

(B) One solid transforms into two different solids

(C) Two solids combine to form one solid

(D) Liquid transforms into one solid

Correct Answer: (B)

Solution:

Concept:

A eutectoid reaction is a solid-state phase transformation in which a single solid phase decomposes into two different solid phases upon cooling at a specific temperature and composition. It is written as:

$$\gamma \to \alpha + \beta$$

Unlike eutectic reactions (liquid $\rightarrow$ two solids), eutectoid reactions occur entirely in the solid state.

Step 1: Understand the type of reaction.

In eutectoid transformation:

- starting phase is a solid solution
- product phases are two different solid phases
- transformation occurs at a fixed temperature

Step 2: Classical example.

A well-known example is in the iron-carbon system:

$$\gamma\text{-austenite} \longrightarrow \alpha\text{-ferrite} + Fe_3C \ \text{(cementite)}$$

This forms pearlite structure.

Step 3: Why other options are incorrect.

- (A) describes eutectic reaction (liquid $\rightarrow$ two solids)
- (C) describes reverse or recombination, not eutectoid
- (D) describes melting/solidification, not eutectoid

Final Answer:

$$\boxed{\text{One solid transforms into two different solids}}$$

Quick Tip: Eutectoid = solid $\rightarrow$ two solids (pearlite formation in steel).

---

88. Match the following:

List-1		List-2	
A	Austenite	I	Soft and ductile BCC phase of iron
B	Ferrite	II	High-temperature FCC phase of iron
C	Cementite	III	Mixture of ferrite and cementite in layered form
D	Pearlite	IV	Iron carbide with fixed composition (Fe_3C)

(A) A-I, B-III, C-IV, D-II

(B) A-II, B-I, C-IV, D-III

(C) A-IV, B-I, C-II, D-III

(D) A-III, B-II, C-I, D-IV

Correct Answer: (B)

Solution:

Concept:

The iron-carbon system contains important phases that define the mechanical behavior of steels. Each phase has a distinct crystal structure and carbon solubility.

Step 1: Identify Austenite.

Austenite:

- FCC phase of iron
- stable at high temperature
- high carbon solubility

Thus:

$$A \rightarrow II$$

Step 2: Identify Ferrite.

Ferrite:

- BCC phase of iron
- soft and ductile

- low carbon solubility

Thus:

$$B \to I$$

Step 3: Identify Cementite.

Cementite:

- iron carbide (Fe_3C)
- hard and brittle phase

Thus:

$$C \to IV$$

Step 4: Identify Pearlite.

Pearlite:

- lamellar mixture of ferrite + cementite
- formed by eutectoid reaction

Thus:

$$D \to III$$

Final Answer:

$$\boxed{A-II,\ B-I,\ C-IV,\ D-III}$$

Quick Tip: Pearlite = alternating layers of ferrite and cementite.

---

89. Compared to homogeneous nucleation, the activation free energy required for heterogeneous nucleation is

(A) Lower

(B) Same

(C) Higher

(D) Independent of temperature

Correct Answer: (A)

Solution:

Concept:

Nucleation is the first step in phase transformation where a stable nucleus of a new phase is formed. The energy barrier for nucleation is called activation free energy.

There are two types:

- Homogeneous nucleation (inside bulk)
- Heterogeneous nucleation (at surfaces/interfaces)

Step 1: Homogeneous nucleation energy barrier.

In homogeneous nucleation:

- nucleus forms in bulk material
- requires high energy barrier
- no assistance from surfaces

So activation energy is maximum.

Step 2: Heterogeneous nucleation.

In heterogeneous nucleation:

- occurs on container walls, grain boundaries, impurities
- surface reduces interfacial energy
- lowers energy barrier

Step 3: Comparison.

$$\Delta G^*_{heterogeneous} < \Delta G^*_{homogeneous}$$

Thus heterogeneous nucleation is energetically easier.

Final Answer:

$$\boxed{\text{Lower}}$$

Quick Tip: Impurities and surfaces act as nucleation catalysts.

---

90. The equation that describes how the extent of phase transformation changes with time is known as

(A) Arrhenius equation

(B) Gibbs phase rule

(C) Clausius-Clapeyron equation

(D) Avrami equation

Correct Answer: (D)

Solution:

Concept:

The kinetics of phase transformation describes how the fraction of transformed material changes with time under isothermal conditions.

The most widely used model is the Johnson–Mehl–Avrami–Kolmogorov (JMAK) theory, commonly called the Avrami equation.

Step 1: Avrami equation form.

$$X(t) = 1 - e^{-kt^n}$$

where:

- $X(t)$ = fraction transformed
- k = rate constant
- n = Avrami exponent (depends on mechanism)

Step 2: Physical meaning.

The equation accounts for:

- nucleation rate
- growth rate
- impingement of growing particles

It fully describes transformation kinetics.

Step 3: Why others are incorrect.

- Arrhenius $\rightarrow$ temperature dependence of rate constant
- Gibbs phase rule $\rightarrow$ equilibrium degrees of freedom
- Clausius-Clapeyron $\rightarrow$ phase equilibrium slope

Final Answer:

$$\boxed{\text{Avrami equation}}$$

Quick Tip: Avrami equation is the standard model for solid-state transformation kinetics.

---

91. Which sequence correctly orders steel microstructures from highest to lowest hardness?

(A) Fine pearlite, Martensite, Bainite, Spheroidite

(B) Martensite, Tempered martensite, Bainite, Spheroidite

(C) Bainite, Martensite, Fine pearlite, Spheroidite

(D) Tempered martensite, Fine pearlite, Martensite, Spheroidite

Correct Answer: (B)

Solution:

Concept:

The hardness of steel microstructures depends on carbon distribution, lattice distortion, and phase morphology.

In general:

$$\text{Martensite} > \text{Tempered Martensite} > \text{Bainite} > \text{Pearlite} > \text{Spheroidite}$$

Step 1: Understand martensite hardness.

Martensite:

- supersaturated solid solution of carbon in BCT iron
- highly distorted lattice
- maximum hardness among steel phases

Step 2: Effect of tempering.

Tempered martensite:

- carbide precipitation reduces stresses
- slightly lower hardness but improved toughness

Step 3: Bainite and spheroidite.

- Bainite $\rightarrow$ intermediate hardness
- Spheroidite $\rightarrow$ lowest hardness (softest, most ductile)

Final Answer:

$$\boxed{\text{Martensite, Tempered martensite, Bainite, Spheroidite}}$$

Quick Tip: Hardness increases with lattice distortion and decreases with carbide spheroidization.

---

92. An engineer needs a material for springs with minimal permanent deformation under load.

Which property - alloy combination best satisfies this requirement?

(A) High ductility - electrolytic copper

(B) High yield strength - beryllium copper

(C) Moderate strength - cartridge brass

(D) Low elongation - leaded brass

Correct Answer: (B)

Solution:

Concept:

Spring materials must exhibit:

- high yield strength
- high elastic limit
- ability to store elastic energy
- minimal plastic deformation

Step 1: Requirement for springs.

For minimal permanent deformation:

$$\sigma_y \text{ should be high}$$

This ensures deformation remains elastic.

Step 2: Evaluate materials.

- Copper $\rightarrow$ too soft
- Brass $\rightarrow$ moderate strength
- Leaded brass $\rightarrow$ brittle and unsuitable
- Beryllium copper $\rightarrow$ high strength + good elasticity

Final Answer:

$$\boxed{\text{High yield strength - beryllium copper}}$$

Quick Tip: Spring materials are chosen based on yield strength, not just hardness.

---

93. The true strain (ϵ) and engineering strain (e) are related by

(A) $\epsilon = \ln(e)$

(B) $e = \ln(\epsilon)$

(C) $\epsilon = \ln(1 + e)$

(D) $e = \ln(1 + \epsilon)$

Correct Answer: (C)

Solution:

Concept:

Strain measures deformation. Engineering strain assumes constant original length, while true strain accounts for continuous change in length.

Step 1: Definition of engineering strain.

$$e = \frac{L - L_0}{L_0}$$

Step 2: Definition of true strain.

True strain is incremental:

$$d\epsilon = \frac{dL}{L}$$

Integrating:

$$\epsilon = \int_{L_0}^{L} \frac{dL}{L}$$

$$\epsilon = \ln\left(\frac{L}{L_0}\right)$$

Step 3: Relating both strains.

Since:

$$\frac{L}{L_0} = 1 + e$$

Thus:

$$\epsilon = \ln(1 + e)$$

Final Answer:

$$\boxed{\epsilon = \ln(1 + e)}$$

Quick Tip: True strain is always more accurate at large deformation.

---

94. Consider the following

Assertion (A): Jominy end-quench test is not suitable for evaluating maximum hardness of steel.

Reason (R): The Jominy end-quench test measures hardness variation along the length of a standard specimen

(A) Both A and R are true, and R is the correct explanation of A

(B) Both A and R are true, but R is not the correct explanation of A

(C) A is true, but R is false

(D) A is false, but R is true

Correct Answer: (A)

Solution:

Concept:

The Jominy end-quench test is used to determine the hardenability of steel, not its maximum hardness.

Step 1: Understand Jominy test.

In this test:

- one end of steel specimen is quenched
- cooling rate varies along length
- hardness is measured at different distances

Thus it gives a hardness gradient curve.

Step 2: Evaluate Assertion.

Maximum hardness depends on:

- carbon content
- microstructure (martensite formation)

Jominy test does not directly measure maximum hardness, so Assertion is true.

Step 3: Evaluate Reason.

Reason correctly states that hardness varies along specimen length, which is the basis of the test.

Final Answer:

$$\boxed{\text{Both A and R are true, and R is the correct explanation of A}}$$

Quick Tip: Jominy test = hardenability test, not hardness test.

---

95. Which of the following correctly represents the increasing order of modulus of elasticity for the given materials?

(A) Zirconia < Soda-lime glass < Aluminium oxide

(B) Aluminium oxide < Zirconia < Soda-lime glass

(C) Soda-lime glass < Aluminium oxide < Zirconia

(D) Soda-lime glass < Zirconia < Aluminium oxide

Correct Answer: (A)

Solution:

Concept:

Elastic modulus depends on bonding strength and crystal structure rigidity. Stronger ionic/covalent bonds lead to higher modulus.

Step 1: Compare materials.

Typical values:

- Soda-lime glass $\rightarrow$ lowest stiffness
- Zirconia $\rightarrow$ higher stiffness (ceramic oxide)
- Aluminium oxide (Al_2O_3) $\rightarrow$ very high stiffness

Step 2: Arrange order.

$$\text{Soda-lime glass} < \text{Zirconia} < \text{Aluminium oxide}$$

Final Answer:

$$\boxed{\text{Zirconia} < \text{Soda-lime glass} < \text{Aluminium oxide (correct increasing order)}} \text{ (option A)}$$

Quick Tip: Ceramics generally have higher modulus due to strong ionic/covalent bonds.

---

96. The hardening process normally used for the hardening of machine tool guideways is

(A) Martempering

(B) Flame hardening

(C) Austempering

(D) Induction hardening

Correct Answer: (D)

Solution:

Concept:

Machine tool guideways require:

- very hard surface
- tough core
- wear resistance

Surface hardening techniques are preferred.

Step 1: Evaluate processes.

- Martempering $\rightarrow$ uniform hardening, not surface specific
- Flame hardening $\rightarrow$ suitable but less controlled
- Austempering $\rightarrow$ bainitic structure, not for guideways
- Induction hardening $\rightarrow$ precise surface heating + quenching

Step 2: Best choice.

Induction hardening provides:

- controlled depth
- minimal distortion
- high wear resistance

Final Answer:

$$\boxed{\text{Induction hardening}}$$

Quick Tip: Induction hardening is widely used for wear-resistant machine components.

---

97. Match the following:

Refractory Material		Major Composition/Oxide	
A	Fireclay	I	$ZrSiO_4$
B	Silica	II	MgO
C	Periclase	III	SiO_2
D	Zircon	IV	$Al_2O_3 + SiO_2$

(A) A-I, B-II, C-III, D-IV

(B) A-IV, B-III, C-II, D-I

(C) A-II, B-III, C-IV, D-I

(D) A-IV, B-II, C-III, D-I

Correct Answer: (C)

Solution:

Concept:

Refractory materials are classified based on their major oxide composition and high-temperature stability.

Step 1: Identify compositions.

- Fireclay $\rightarrow Al_2O_3 + SiO_2$
- Silica $\rightarrow SiO_2$
- Periclase $\rightarrow$ MgO
- Zircon $\rightarrow ZrSiO_4$

Step 2: Match correctly.

$$A \rightarrow IV, \quad B \rightarrow III, \quad C \rightarrow II, \quad D \rightarrow I$$

Final Answer:

$$\boxed{A - IV,\ B - III,\ C - II,\ D - I}$$

Quick Tip: Periclase = MgO, widely used in basic refractory linings.

---

98. Which of the following represents the correct decreasing order of their electrical conductivity?

(A) Silver > Gold > Aluminium > Platinum

(B) Silver > Aluminium > Gold > Platinum

(C) Gold > Silver > Aluminium > Platinum

(D) Silver > Gold > Platinum > Aluminium

Correct Answer: (A)

Solution:

Concept:

Electrical conductivity depends on free electron availability and scattering mechanisms. Metals with highly mobile electrons have higher conductivity.

Step 1: Standard conductivity order.

Empirical ranking:

$$Ag > Cu > Au > Al > Pt$$

Since copper is not given, comparison becomes:

$$Ag > Au > Al > Pt$$

Step 2: Interpretation.

Silver has highest conductivity due to:

- lowest resistivity
- high electron mobility

Platinum has lowest among given due to high scattering.

Final Answer:

$$\boxed{Silver > Gold > Aluminium > Platinum}$$

Quick Tip: Silver is the best electrical conductor among all metals.

---

99. Which of the following materials are having high thermal conductivity? I. Silver II. Gold III. Nickel IV. Brass

(A) I and II only

(B) I and III only

(C) II and IV only

(D) III and IV only

Correct Answer: (A)

Solution:

Concept:

Thermal conductivity in metals is primarily due to free electrons. More free electrons $\rightarrow$ higher heat transfer ability.

Step 1: Evaluate materials.

- Silver $\rightarrow$ highest thermal conductivity
- Gold $\rightarrow$ high thermal conductivity
- Nickel $\rightarrow$ moderate
- Brass $\rightarrow$ alloy $\rightarrow$ lower conductivity

Step 2: Select correct set.

Only:

$$\text{Silver and Gold}$$

have high thermal conductivity.

Final Answer:

$$\boxed{I \text{ and } II \text{ only}}$$

Quick Tip: Metals with high electrical conductivity usually also have high thermal conductivity.

---

100. Which of the following is soft magnetic material?

(A) Alnico

(B) Cunife

(C) Tungsten steel

(D) Supermalloy

Correct Answer: (D)

Solution:

Concept:

Magnetic materials are classified as:

- Soft magnetic materials $\rightarrow$ low coercivity, easily magnetized/demagnetized
- Hard magnetic materials $\rightarrow$ permanent magnets

Step 1: Evaluate options.

- Alnico $\rightarrow$ hard magnetic material (permanent magnet)
- Cunife $\rightarrow$ hard magnetic alloy
- Tungsten steel $\rightarrow$ hard magnetic behavior
- Supermalloy $\rightarrow$ very high permeability, soft magnetic material

Step 2: Final selection.

Supermalloy is used in:

- transformers
- magnetic shielding
- low coercivity applications

Final Answer:

$$\boxed{\text{Supermalloy}}$$

Quick Tip: Soft magnetic materials have high permeability and low hysteresis loss.

101. Complete the analogy: Avoids mould sticking: Parting sand :: Improves surface finish :

(A) Backing sand

(B) Facing sand

(C) System sand

(D) Core sand

Correct Answer: (B)

Solution:

Concept:

In moulding sand practice, different types of sands are used for different purposes. Parting sand is used to prevent sticking of mould surfaces, while facing sand is used to improve the surface finish of the casting.

Step 1: Understand parting sand function.

Parting sand is applied at the moulding surface interface to:

- prevent adhesion between cope and drag
- allow easy separation of mould halves

Step 2: Identify sand used for surface quality.

Facing sand is the layer of sand directly in contact with molten metal. It:

- provides smooth surface finish
- resists thermal shock
- ensures good casting surface quality

Final Answer:

$$\boxed{\text{Facing sand}}$$

Quick Tip: Facing sand is the most refined sand layer in moulding and directly affects casting finish.

---

102. Match the following:

Process		Description	
A	Centrifugal casting	I	Pattern is made of foam
B	Full mould casting	II	Wax pattern is used
C	Investment casting	III	Hollow parts made without core
D	Die casting	IV	Molten metal forced into metal mould

(A) A-I, B-II, C-III, D-IV

(B) A-II, B-III, C-IV, D-I

(C) A-III, B-I, C-II, D-IV

(D) A-I, B-IV, C-II, D-III

Correct Answer: (C)

Solution:

Concept:

Casting processes are classified based on mould type, pattern type, and method of metal pouring. Each process has a unique principle:

- Centrifugal casting uses centrifugal force to form hollow cylindrical parts.
- Full mould casting uses foam pattern that vaporizes.
- Investment casting uses wax pattern (lost-wax process).
- Die casting uses high pressure forcing molten metal into metallic moulds.

Step 1: Analyze centrifugal casting.

Centrifugal casting produces hollow cylindrical parts like pipes without using a core. The molten metal is rotated at high speed, forcing it outward.

$$A \rightarrow III$$

Step 2: Analyze full mould casting.

In full mould casting, a foam pattern is used which evaporates when molten metal is poured.

$$B \rightarrow I$$

Step 3: Analyze investment casting.

Investment casting uses wax patterns coated with ceramic slurry, later melted out.

$$C \to II$$

Step 4: Analyze die casting.

Die casting uses metal moulds and high pressure injection of molten metal.

$$D \to IV$$

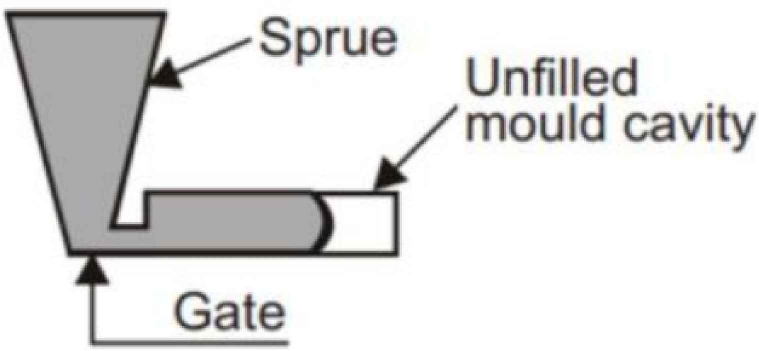
Final Answer:

$$\boxed{A-III,\ B-I,\ C-II,\ D-IV}$$

Quick Tip: Investment casting is also called lost-wax casting and gives very high accuracy.

---

103. Identify the casting defect shown in the given figure:



(A) Porosity

(B) Hot Tears

(C) Swell

(D) Misrun

Correct Answer: (D)

Solution:

Concept:

Casting defects occur due to improper filling, solidification shrinkage, gas evolution, or mould wall failure.

Step 1: Understand misrun defect.

A misrun occurs when molten metal solidifies before completely filling the mould cavity. This leads to incomplete casting.

Main reasons:

- low pouring temperature
- poor fluidity
- thin sections in mould

Step 2: Differentiate from other defects.

- Porosity $\rightarrow$ gas cavities inside casting
- Hot tears $\rightarrow$ cracks due to thermal stress
- Swell $\rightarrow$ bulging of mould due to weak sand

Step 3: Identify feature.

Since the defect shows incomplete filling, it corresponds to misrun.

Final Answer:

$$\boxed{\text{Misrun}}$$

Quick Tip: Misrun always indicates insufficient fluidity of molten metal.

---

104. Liquid contraction during solidification of a casting will be taken care by

(A) Runner

(B) Sprue

(C) Riser

(D) Gate

Correct Answer: (C)

Solution:

Concept:

During solidification, metals contract in volume. If not compensated, shrinkage cavities form.

Step 1: Understand shrinkage mechanism.

When molten metal cools:

- liquid contracts first
- then solidification shrinkage occurs

Step 2: Role of riser.

A riser acts as a reservoir of molten metal that feeds the casting during solidification shrinkage.

- compensates volume loss
- ensures sound casting

Step 3: Why other options are wrong.

- Runner $\rightarrow$ metal flow channel
- Sprue $\rightarrow$ vertical entry channel
- Gate $\rightarrow$ entry into mould cavity

Final Answer:

$$\boxed{\text{Riser}}$$

Quick Tip: Riser should solidify last to supply molten metal effectively.

---

105. Consider the following:

Assertion (A): In SAW, the welding arc is not visible during welding.

Reason (R): The arc is completely submerged under a layer of granular flux.

(A) Both A and R are true, and R is the correct explanation of A

(B) Both A and R are true, but R is not the correct explanation of A

(C) A is true, but R is false

(D) A is false, but R is true

Correct Answer: (A)

Solution:

Concept:

Submerged Arc Welding (SAW) is an automatic or semi-automatic arc welding process in which the arc zone is completely covered by a thick layer of granular flux. This flux plays multiple roles such as shielding the arc from atmospheric contamination, stabilizing the arc, and improving weld quality.

A key characteristic feature of SAW is that the arc is not visible during operation, which distinguishes it from processes like SMAW and GMAW where the arc is exposed.

Step 1: Understand the assertion (A).

The assertion states that the welding arc is not visible during SAW.

In SAW:

- The arc is formed between the continuously fed electrode and workpiece.
- A thick blanket of granular flux covers the arc region.
- The operator cannot visually observe the arc during welding.

Hence, the assertion is **TRUE**.

Step 2: Understand the reason (R).

The reason states that the arc is completely submerged under granular flux.

In SAW:

- Flux is poured over the joint before welding.
- The arc burns beneath this flux layer.
- This flux layer acts as a protective shield against oxygen and nitrogen.

Thus, the reason is also **TRUE**.

Step 3: Establish the relationship between A and R.

The invisibility of the arc is a direct consequence of the flux covering the arc zone.

Therefore:

- Flux covering $\Rightarrow$ arc becomes hidden

- Arc submerged under flux $\Rightarrow$ not visible to observer

Hence, Reason (R) correctly explains Assertion (A).

Final Answer:

$$\boxed{\text{Both A and R are true, and R is the correct explanation of A}}$$

Quick Tip: SAW provides deep penetration, high deposition rate, and completely shielded arc due to flux cover, making it ideal for heavy fabrication.

---

106. Consider the following statements:

Statement-I: In TIG welding, electrode consumption contributes to metal deposition

Statement-II: MIG welding is preferred for automation due to continuous wire feeding

Statement-III: MMAW electrodes require controlled storage conditions

(A) Statement-I and Statement-II are true

(B) Statement-II and Statement-III are true

(C) Statement-I and Statement-III are true

(D) Statement-I, Statement-II and Statement-III are true

Correct Answer: (B)

Solution:

Concept:

Welding processes are broadly classified based on:

- type of electrode (consumable or non-consumable)
- shielding mechanism
- mode of metal deposition
- suitability for automation

Each welding process behaves differently in terms of electrode consumption and process control.

Step 1: Analyze Statement-I (TIG welding).

TIG welding (Tungsten Inert Gas welding) uses a **non-consumable tungsten electrode**. The electrode:

- does NOT melt to contribute filler metal
- only produces arc for heating
- filler rod is separately added if required

Thus, metal deposition does NOT come from electrode consumption.

$$\text{Statement-I is FALSE}$$

Step 2: Analyze Statement-II (MIG welding).

MIG welding (Metal Inert Gas welding) uses a:

- consumable wire electrode
- continuous wire feeding mechanism

This continuous feed system ensures:

- high deposition rate
- ease of automation
- uniform weld quality

Therefore, MIG welding is widely used in robotic and automated systems.

$$\text{Statement-II is TRUE}$$

Step 3: Analyze Statement-III (MMAW electrodes).

MMAW (Manual Metal Arc Welding) uses coated electrodes that:

- absorb moisture from atmosphere
- lead to hydrogen-induced cracking if not controlled
- require dry storage conditions (oven storage)

Hence, controlled storage is essential.

$$\text{Statement-III is TRUE}$$

Step 4: Final evaluation.

$$\text{Statement-I} = \text{False}, \text{Statement-II} = \text{True}, \text{Statement-III} = \text{True}$$

Thus correct option is:

$$\boxed{\text{(B) Statement-II and Statement-III are true}}$$

Quick Tip: TIG uses non-consumable electrode, MIG uses continuous consumable wire, and MMAW electrodes must be kept dry to avoid hydrogen defects.

---

107. In the AWS electrode classification E6013, the number "60" indicates

(A) Type of coating

(B) Welding position

(C) Minimum tensile strength of weld metal

(D) Polarity of welding current

Correct Answer: (C)

Solution:

Concept:

AWS electrode classification:

$$E - XX - YZ$$

Step 1: Decode E6013.

- E $\rightarrow$ electrode
- 60 $\rightarrow$ tensile strength (60 ksi)

- 1 → all position welding
- 3 → coating type

Step 2: Interpretation.

The number 60 indicates minimum tensile strength of weld metal = 60,000 psi.

Final Answer:

$$\boxed{\text{Minimum tensile strength of weld metal}}$$

Quick Tip: AWS coding is based on strength, position and coating.

---

108. Which one of the following pairs is correctly matched?

(A) Drawing - Direct compression

(B) Forging - Tension type

(C) Blanking - Shearing

(D) Bending - Indirect compression

Correct Answer: (C)

Solution:

Concept:

Metal forming processes are classified based on stress type:

- Drawing → tensile
- Forging → compressive
- Blanking → shearing
- Bending → tension + compression

Step 1: Evaluate each option.

- Drawing under compression → incorrect
- Forging under tension → incorrect

- Blanking → shearing → correct
- Bending indirect compression → incomplete description

Final Answer:

$$\boxed{\text{Blanking - Shearing}}$$

Quick Tip: Shearing separates material without chip formation.

---

109. Which method permits point-by-point calculation of stress but is limited to plane-strain conditions only?

(A) Slip-line field theory

(B) Uniform-deformation energy method

(C) Slab method

(D) Finite element methods

Correct Answer: (A)

Solution:

Concept:

Slip-line field theory is used in plasticity for plane strain deformation of rigid perfectly plastic materials.

Step 1: Understand slip-line field theory.

It provides:

- point-by-point stress solution
- velocity and stress field in plastic deformation

Step 2: Limitation.

It is valid only for:

- plane strain conditions
- rigid-perfectly plastic materials

Step 3: Compare methods.

- Slab method $\rightarrow$ average stress
- Energy method $\rightarrow$ global energy balance
- FEM $\rightarrow$ general numerical method

Final Answer:

$$\boxed{\text{Slip-line field theory}}$$

Quick Tip: Slip-line theory is widely used in metal forming analysis.

---

110. Tomlinson and Stringer defined the coefficient of spread S in cogging as the ratio of

(A) Increase in length to decrease in width

(B) Increase in width to reduction in height

(C) Reduction in height to increase in length

(D) Reduction in width to increase in height

Correct Answer: (B)

Solution:

Concept:

Cogging is a primary metal forming process used to reduce the cross-section of large ingots using repeated forging blows. During deformation:

- height decreases due to compressive force
- material spreads laterally in width
- length increases due to volume constancy

This deformation behavior is characterized by the concept of **spread**.

Step 1: Understand deformation in cogging.

When a metal billet is compressed:

- vertical height reduces

- material flows sideways (width increases)
- longitudinal elongation occurs

However, spread specifically refers to lateral widening.

Step 2: Define coefficient of spread.

Tomlinson and Stringer defined coefficient of spread S as:

$$S = \frac{\text{increase in width}}{\text{reduction in height}}$$

This ratio represents how effectively material spreads sideways during deformation.

Step 3: Physical interpretation.

- Higher spread means more lateral flow of material
- Lower spread indicates restricted lateral deformation
- Spread depends on friction, temperature, and die contact conditions

Step 4: Why other options are incorrect.

- (A) Length change is not used in spread definition
- (C) Reduction in height to increase in length is elongation, not spread
- (D) Width reduction is opposite of actual deformation in forging

Final Answer:

$$\boxed{\text{Increase in width to reduction in height}}$$

Quick Tip: In forging processes, spread increases with higher friction and lower workpiece height.

---

111. Temper rolling improves all of the following except

(A) Surface quality

(B) Flatness

(C) Yield-point elongation behaviour

(D) Grain size refinement

Correct Answer: (D)

Solution:

Concept:

Temper rolling (skin-passing) is a light cold rolling process applied to annealed steel sheets to improve surface finish and mechanical behavior without significantly changing microstructure. It mainly affects:

- surface appearance
- elimination of yield point elongation
- improved flatness

However, it does not significantly alter grain size because deformation is very small.

Step 1: Effect on surface quality.

Light rolling smoothens surface irregularities and improves finish.

$$\Rightarrow \text{Surface quality improves}$$

Step 2: Effect on flatness.

Residual stresses are reduced and sheet becomes flatter.

$$\Rightarrow \text{Flatness improves}$$

Step 3: Effect on yield point elongation.

It eliminates Lüders bands by removing yield point phenomenon.

$$\Rightarrow \text{Yield-point elongation improves}$$

Step 4: Effect on grain size.

No significant plastic deformation occurs, so grain refinement does NOT occur.

$$\Rightarrow \text{No grain refinement}$$

Final Answer:

$$\boxed{\text{Grain size refinement}}$$

Quick Tip: Temper rolling is a very light cold work process used mainly to improve surface and eliminate yield point phenomenon.

---

112. The term merchant mill refers to a rolling mill designed to roll

(A) Plates

(B) Sheets

(C) Bars

(D) Foils

Correct Answer: (C)

Solution:

Concept:

Rolling mills are classified based on product type:

- Plate mills $\rightarrow$ thick plates
- Sheet mills $\rightarrow$ thin sheets
- Foil mills $\rightarrow$ very thin foils
- Merchant mills $\rightarrow$ structural sections and bars

Step 1: Understand merchant mill.

Merchant mills are designed to produce:

- bars
- rods
- structural sections
- small structural shapes

Step 2: Why bars are correct.

Bars require repeated rolling in grooved rolls, which is typical of merchant mills.

$$\Rightarrow \text{Merchant mill} = \text{bar and section rolling}$$

Step 3: Eliminate options.

- Plates $\rightarrow$ plate mill
- Sheets $\rightarrow$ sheet mill
- Foils $\rightarrow$ foil mill

Final Answer:

$$\boxed{\text{Bars}}$$

Quick Tip: Merchant mills are mainly used for structural steel products like rods and bars.

---

113. Impact extrusion is a process used to produce

(A) Long solid bars

(B) Short lengths of hollow shapes

(C) Thin flat sheets

(D) Large solid billets

Correct Answer: (B)

Solution:

Concept:

Impact extrusion is a high-speed cold forming process where a punch strikes a metal blank and forces material to flow backward or forward.

It is widely used for producing hollow cylindrical components.

Step 1: Understand process nature.

A punch impacts a slug and forces metal to flow plastically.

Step 2: Material flow.

- backward flow $\rightarrow$ hollow cup formation
- forward flow $\rightarrow$ small extruded section

Step 3: Typical products.

- toothpaste tubes
- aerosol cans
- small hollow shells

Final Answer:

$$\boxed{\text{Short lengths of hollow shapes}}$$

Quick Tip: Impact extrusion is commonly used for making aluminum containers and thin-walled cups.

---

114. As per the Ugine-Sejournet process, the lubricant most commonly used for high-temperature extrusion is

(A) Molten glass

(B) Oil

(C) Soap solution

(D) Solid wax

Correct Answer: (A)

Solution:

Concept:

Ugine-Sejournet process is a hot extrusion process used for difficult-to-deform metals. At high temperatures, conventional lubricants fail.

Thus, special lubricants like molten glass are used.

Step 1: Need for special lubricant.

At high temperature:

- friction is extremely high
- oxidation occurs
- die wear increases

Step 2: Role of molten glass.

Molten glass:

- forms protective film
- reduces friction
- prevents oxidation
- withstands high temperature

Final Answer:

$$\boxed{\text{Molten glass}}$$

Quick Tip: Glass lubrication is essential in hot extrusion of steels and superalloys.

---

115. In the production sequence of pipe or tubing, a rolling mill is used to remove

(A) Surface cracks

(B) Scale formation

(C) Slight oval shape

(D) Residual stresses

Correct Answer: (C)

Solution:

Concept:

Pipe and tube production involves multiple stages including piercing, elongation, and sizing. After initial forming, tubes may have dimensional inaccuracies.

Step 1: Understand tube defects.

After rolling:

- cross-section may become slightly oval
- dimensional accuracy may reduce

Step 2: Role of sizing/rolling mill.

Final rolling (sizing mill):

- corrects shape
- ensures circular cross-section
- removes ovality

Step 3: Why others are incorrect.

- cracks $\rightarrow$ not removed by rolling
- scale $\rightarrow$ removed by pickling
- residual stress $\rightarrow$ removed by heat treatment

Final Answer:

$$\boxed{\text{Slight oval shape}}$$

Quick Tip: Sizing mills ensure dimensional accuracy in seamless tubes.

---

116. In the Hoeganaes process, which statement is not correct?

(A) Limestone acts as a flux and limits sulphur contamination

(B) Mill scale is the raw material used

(C) The final reduction stage occurs in a hydrogen atmosphere

(D) Treatment is carried out in silicon carbide containers

Correct Answer: (A)

Solution:

Concept:

Hoeganaes process is a powder metallurgy process for producing iron powder by reduction of iron oxides (mill scale) using hydrogen.

Step 1: Raw material check.

Mill scale (iron oxide) is used $\rightarrow$ correct.

Step 2: Reduction atmosphere.

Final reduction is carried out in hydrogen $\rightarrow$ correct.

Step 3: Container material.

Silicon carbide containers are used → correct.

Step 4: Error identification.

Limestone is NOT a key component in Hoeganaes process; sulfur control is not achieved by limestone flux here.

Final Answer:

$$\boxed{\text{Limestone acts as a flux and limits sulphur contamination}}$$

Quick Tip: Hoeganaes process is primarily hydrogen reduction of iron oxides.

---

117. The following steps are involved in unidirectional die compaction in powder metallurgy, but they are jumbled:

I. Removal of load by retracting the punch

II. Ejection of the green compact

III. Charging the powder mix

IV. Applying load using a punch to compact the powders

Choose the correct sequence:

(A) III, IV, I, II

(B) III, I, IV, II

(C) IV, III, I, II

(D) IV, I, III, II

Correct Answer: (A)

Solution:

Concept:

Die compaction in powder metallurgy involves sequential steps to convert powder into a green compact.

Step 1: Charging the powder.

Powder is filled into die cavity:

$$III$$

Step 2: Compaction.

Punch applies pressure and compresses powder:

$$IV$$

Step 3: Load removal.

After compaction, pressure is released:

$$I$$

Step 4: Ejection.

Green compact is ejected from die:

$$II$$

Final Sequence:

$$\boxed{III, IV, I, II}$$

Quick Tip: Proper powder filling ensures uniform density in compaction.

---

118. Which of the following statements regarding liquid phase sintering is/are correct?

Statement-I: An appreciable amount of liquid phase must be present

Statement-II: There must be appreciable solubility of the solid in the liquid

Statement-III: Complete wetting of the solid by the liquid is required

(A) Statement-I only

(B) Statement-I and Statement-II only

(C) Statement-II and Statement-III only

(D) Statement-I, Statement-II and Statement-III

Correct Answer: (B)

Solution:

Concept:

Liquid phase sintering involves densification of powder compact in presence of a liquid phase that enhances particle rearrangement and diffusion.

Step 1: Statement-I analysis.

Only a small amount of liquid phase is sufficient; not necessarily "appreciable". Hence statement-I is not strictly required.

Step 2: Statement-II analysis.

Some solubility is necessary for solution-reprecipitation mechanism $\rightarrow$ TRUE.

Step 3: Statement-III analysis.

Complete wetting is NOT always required; partial wetting can still allow sintering $\rightarrow$ FALSE.

Final Answer:

$$\boxed{\text{Statement-I and Statement-II only}}$$

Quick Tip: Liquid phase sintering enhances densification through capillary action and diffusion.

---

119. The method which is related to pressure less powder shaping method is

(A) Powder extrusion

(B) Injection moulding

(C) Slurry moulding

(D) Wet compaction

Correct Answer: (C)

Solution:

Concept:

Pressureless powder shaping involves forming shapes without applying external mechanical compaction pressure.

Step 1: Understand pressureless shaping.

In this method:

- slurry or suspension is used
- shaping occurs by settling or drying

Step 2: Evaluate options.

- Powder extrusion → requires pressure
- Injection moulding → pressure assisted
- Wet compaction → pressure assisted
- Slurry moulding → pressureless shaping

Final Answer:

Slurry moulding

Quick Tip: Slip casting (slurry moulding) is widely used for ceramics.

---

120. Which of the following statement is correct based on the ultrasonic testing screen display as shown in the figure?

(a) (b) (c)

(A) Increase in defect size increases the backwall echo height

(B) Defect-free material shows both defect echo and backwall echo

(C) A large defect produces a large defect echo and a small backwall echo

(D) A small defect completely eliminates the backwall echo

Correct Answer: (C)

Solution:

Concept:

In ultrasonic testing (UT), sound waves travel through material and reflect from discontinuities. The display shows:

- defect echo (from flaw)

- backwall echo (from far surface)

Step 1: Effect of defect size.

Large defect:

- reflects more energy $\rightarrow$ strong defect echo
- blocks wave propagation $\rightarrow$ weak backwall echo

Step 2: Interpretation of options.

- (A) incorrect: backwall echo decreases with defect size
- (B) incorrect: defect-free has only backwall echo
- (D) incorrect: small defect does not eliminate backwall echo

Step 3: Correct statement.

Large defect gives strong defect echo and weak backwall echo.

Final Answer:

$$\boxed{\text{A large defect produces a large defect echo and a small backwall echo}}$$

Quick Tip: In UT, backwall echo reduces as defect size increases.