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MECHANICAL ENGINEERING

Objective Practice Sets

Material Science

1 CHAPTER
Structures of Metals and Alloys

MCQ and NAT Questions

Q.1 For Molybdenum, which has a body centered cubic lattice structure, the number of atoms per unit cell is
(a) 1 (b) 2
(c) 4 (d) 6

Q.2 A plane intersects the coordinate axes at $x = \frac{2}{3}, y = \frac{1}{3}, z = \frac{1}{2}$, then its miller indices is
(a) (932) (b) (452)
(c) (413) (d) (364)

Q.3 Specify the sequence correctly
(a) Grain growth, recrystallization, stress relief
(b) Stress relief, grain growth, recrystallization
(c) Stress relief, recrystallization, grain growth
(d) Grain growth, stress relief, recrystallization

Q.4 Assuming atoms to be perfect spheres, what is the value of the highest possible atomic packing factor (APF) in metals ?
(a) 0.95 (b) 0.74
(c) 0.66 (d) 0.5

Q.5 An infinite array of points in three-dimensional space in which each point is identically located with respect to the other is known as
(a) space lattice (b) Basis
(c) Unit cell (d) Crystal

Q.6 Atomic packing factor for chromium will be equal to
(a) 0.523 (b) 0.68
(c) 0.74 (d) 0.84

Q.7 Miller indices (101) is
(a) parallel to x-axis (b) parallel to y-axis
(c) parallel to z-axis (d) None of the above

Q.8 When a pair of one cation & one anion are absent from an ionic crystal, the defect is called as
(a) Substitutional impurity
(b) Interstitial impurity
(c) Frenkel's defect
(d) Schottky's defect

Q.9 Ratio of elastic strain energy of an edge dislocation to the screw dislocation is
(a) $(1-\nu)$ (b) $\frac{1}{(1-\nu)}$
(c) $\left(\frac{1-\nu}{1+\nu}\right)$ (d) $\left(\frac{1+\nu}{1-\nu}\right)$

Q.10 Match **List-I** (Crystal structure) with **List-II** (Atomic packing factor) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Simple cubic	1. 74%
B. Body-Centred cubic	2. 74%
C. Face-Centred cubic	3. 52%
D. Hexagonal close packed	4. 68%

Codes:

	A	B	C	D
(a)	3	4	2	1
(b)	4	3	2	1
(c)	3	4	1	2
(d)	4	3	1	2

Q.11 The ratio of long and short unit cell dimensions of ideal HCP crystal structure should be
(a) 1.56 (b) 1.89
(c) 1.633 (d) 1.59

Q.12 Cubic closed Packed (CCP) is also known as
(a) SC (b) BCC
(c) FCC (d) BCT

Q.13 Phenomenon of cross-slip occurs in
(a) edge dislocation
(b) screw dislocation
(c) mixed dislocation
(d) edge & mixed dislocation

Q.14 Which one of the following is not correct about the characteristics of dislocation?
(a) Edge dislocations travel much faster than screw dislocations
(b) Two edge dislocations of opposite sign, of equal Burgers vector & on the same slip plane cancel out.

(c) The elastic strain energy per unit length of a dislocation is directly proportional to the burgers vector 'b'
(d) The sum of Burgers vectors meet at a point called nodal point, inside the crystal remains zero.

Q.15 A miller indices of the diagonal plane of cube is
(a) (200) (b) (111)
(c) (010) (d) $(\bar{1}10)$

Q.16 The crystal structure of austenite is
(a) body centered cubic
(b) face centered cubic
(c) hexagonal closed packed
(d) body centered tetragonal

Q.17 Crystal structure of metals is studied by
(a) metallographic techniques
(b) X-ray techniques
(c) electron microscopy
(d) high powered microscope

Q.18 Match **List-I** (Crystal Structure) with **List -II** (Example) and select the correct answer:

	List-I		List-II
A.	Simple Cubic	1.	Zinc
B.	Body-centered Cubic	2.	Copper
C.	Face-centered Cubic	3.	Alpha iron at room temperature
D.	Hexagonal Close	4.	Manganese Packed

Codes:

	A	B	C	D
(a)	4	3	1	2
(b)	4	3	2	1
(c)	3	4	2	1
(d)	3	4	1	2

Q.19 Consider the following statements about edge dislocation:
1. It appears when there is an extra incomplete plane of atom in crystal.
2. Burger's vector is perpendicular to the dislocation edge.

Which of the above statements are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q.20 Consider the following statements about screw dislocation:
1. It forms when crystal displaces angularly over the remaining parts.
2. Burgers vector is parallel to screw dislocation line.
3. Screw dislocations are symbolically represented by clockwise & anticlock-wise and referred on negative & positive screw dislocation respectively

Which of the above statement are correct?
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

Q.21 Match **List-I** with **List-II** and select the correct answer given below the lists:

	List-I		List-II
A.	BCC	1.	Zn
B.	FCC	2.	Po
C.	SC	3.	Ni
D.	HCP	4.	Na

Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	3	4	1	2
(c)	3	4	2	1
(d)	4	3	1	2

Q.22 What is the approximate strain energy expression for a dislocation of unit length, irrespective of its edge or screw character?
(a) $\frac{G^2b}{2}$ (b) $\frac{Gb^2}{2}$
(c) $\frac{G^2b}{4}$ (d) $\frac{Gb^2}{4}$

Q.23 Which one of the following is correct for 'Climb'?
(a) Dislocation moves parallel to the slip plane
(b) Dislocation moves perpendicular to the slip plane
(c) Sliding of one plane of atoms over the other plane
(d) Dislocation moves from a slip plane to another slip plane

Q.24 Match **List-I** with **List-II** and select the correct answer given below the lists:

List-I (Miller indices)	List-II (Denotes)
A. (h k *l*)	1. direction
B. [h k *l*]	2. plane
C. {h k *l*}	3. family of directions
D. <h k *l*>	4. Family of planes

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	1	2	4	3
(c)	2	1	4	3
(d)	2	1	3	4

Q.25 Match **List-I** with **List-II** and select the correct answer given below the lists:

List-I

A. Point Imperfection
B. Line Imperfection
C. Surface or planer Imperfection
D. Volume Imperfection

List-II

1. Pores
2. Twinning
3. Frenkel defect
4. Mixed imperfection/dislocation

Codes:

	A	B	C	D
(a)	3	4	2	1
(b)	3	4	1	2
(c)	4	3	1	2
(d)	4	3	2	1

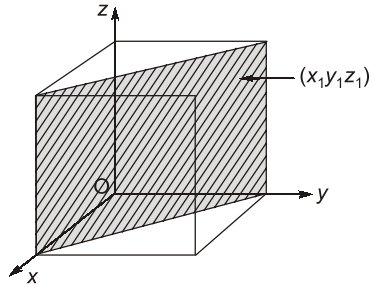
Q.26 The defect responsible for the phenomena of slip, by which most metals deform plastically, is known as

(a) fracture
(b) twinning
(c) dislocation
(d) strain hardening

Q.27 The effective number of lattice points in the unit cell of simple cubic, body centered cubic and face centered cubic space lattices respectively are

(a) 1, 2, 2 (b) 1, 2, 4
(c) 2, 3, 4 (d) 2, 4, 4

Q.28 Miller Indices (*x*, *y*, *z*) for the hatched plane in the below unit cell are represented as



(a) (1 0 0) (b) (1 1 0)
(c) (1 1 1) (d) (1 0 1)

Q.29 Line imperfection in a crystal is called

(a) Miller defect (b) Frenkel defect
(c) Schottky defect (d) Edge dislocation

Q.30 X-ray with a wavelength λ are used for calculating d_{200} in nickel. The reflection angle is 8° and the order of reflection is 1. What will be the lattice parameter?

(a) 5.3890λ (b) 0.1391λ
(c) 3.5926λ (d) 7.1853λ

Q.31 Motion of dislocation in screw dislocation and edge dislocations are termed as

(a) climb and glide respectively
(b) glide and climb respectively
(c) glide and glide respectively
(d) climb and climb respectively

Q.32 Match **List-I** with **List-II** and select the correct answer given below the lists:

List-I	List-II
A. Allotropy	1. Identical properties at all direction in a body
B. Isotropic	2. A continuous body with no void
C. Anisotropic	3. Doesn't have identical properties
D. Homogeneous	4. Element in more than one lattice form

Codes:

	A	B	C	D
(a)	4	3	1	2
(b)	4	1	3	2
(c)	2	1	3	4
(d)	2	3	1	4

Q.65 An alkali halide is having NaCl structure and having density as 2.1145 g/cm^3. Which of the following statements is(are) correct?

(a) If it contain 0.1% Schottky defect then its density will be 2.11239 g/cm^3.

(b) If it contain 0.1% Frenkel defect then its density will be 2.11239 g/cm^3.

(c) If it contain 0.1% Frenkel defect then its density will be 2.1145 g/cm^3.

(d) If it contain 0.1% Schottky defect then its density will be 2.1145 g/cm^3.

■■■■

Answers Structures of Metals and Alloys

1. (b)	2. (d)	3. (c)	4. (b)	5. (a)	6. (b)	7. (b)
8. (d)	9. (b)	10. (a, c)	11. (c)	12. (c)	13. (b)	14. (c)
15. (b)	16. (b)	17. (b)	18. (b)	19. (c)	20. (a)	21. (a)
22. (b)	23. (b)	24. (c)	25. (d)	26. (c)	27. (b)	28. (b)
29. (d)	30. (d)	31. (a)	32. (b)	33. (a)	34. (b)	35. (a)
36. (c)	37. (b)	38. (b)	39. (c)	40. (a)	41. (c)	42. (d)
43. (c)	44. (a)	45. (d)	46. (d)	47. (a)	48. (c)	49. (c)
50. (a)	51. (d)	52. (d)	53. (0.68)	54. (a, c, d)	55. (a, b, d)	56. (a, d)
57. (a, d)	58. (c, d)	59. (c)	60. (b, c, d)	61. (a, c)	62. (a, b, c, d)	63. (a, c)
64. (a, b, c, d)		65. (a, c)				

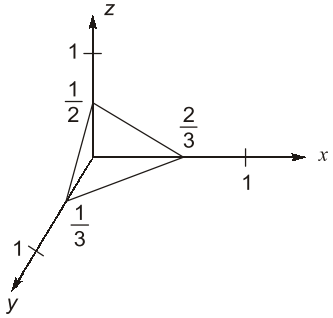
Explanations Structures of Metals and Alloys

1. (b)

Crystal structure	Effective No. of atoms in unit cell
* Diamond cubic	8
* Simple cubic	1
* Face centered	4
* HCP	6
* BCC	2

2. (d)

Taking reciprocal of intercepts on x, y and z axis, we have $\left(\frac{3}{2}, 3, 2\right)$ and forming fractions into integer, we have (364) as miller indices of this plane.



3. (c)

Stress relief involves removing stresses in a material usually by heating it to a temperature at which it can deform easily.

Recrystallization is a procedure by which deformed grains are replaced by a new set of defect free grain that nucleate and grow until the original grain have been entirely consumed.

Grain growth is the increase in the size of grain in a material at high temperature. This occurs when recovery and recrystallization are complete.

4. (b)

The atomic packing factor of simple cubic = 0.52
Atomic packing factor of BCC = 0.68
Atomic packing factor of FCC = 0.74
Atomic packing factor of HCP = 0.74
Atomic packing factor of diamond structure = 0.34

5. (a)

An infinite array of points in three-dimensional space in which each point is identically located with respect to the other is called space lattice.

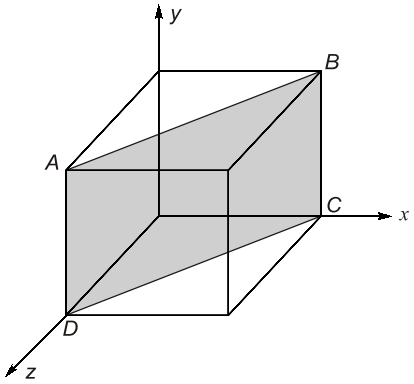
6. (b)

$$APF = \frac{4\pi r^3 \times Ne}{3V} = \frac{4\pi r^3 \times 2}{3a^3}$$

$$= \frac{4\pi r^3 \times 2}{3(4r/\sqrt{3})^3} \qquad \left(\therefore r = \frac{a\sqrt{3}}{4}\right) = 0.68$$

7. (b)

Miller indicates (101), will not any intercept on *y*-axis so will be parallel to plane *y*-axis.



8. (d)

If in an ionic crystal of the type A^+B^- equal number of cations and anions are missing from their lattice site, so that the electrical neutrality is maintained, it is called Schottky's defect. It is a point defect.

9. (b)

Elastic strain energy of screw dislocation,

$$E_s = \frac{Gb^2}{4\pi}\ln\frac{R}{r_0}$$

Elastic strain energy of edge dislocation,

$$E_e = \frac{Gb^2}{4\pi(1-\nu)}\ln\frac{R}{r_0}$$

$$\text{Ratio} = \frac{E_e}{E_s} = \frac{1}{1-\nu}$$

10. (a, c)

In crystallography, atomic packing factor (APF) or packing efficiency is the fraction of volume in a crystal structure that is occupied by the constituent particles. It is a dimensionless quantity.

$$\text{APF} = \frac{N_{\text{atoms}} \times N_{\text{atoms}}}{V_{\text{unit cell}}}$$

APF for different structures is given below:

Crystal structure	:	APF
Simple cubic	:	0.52
BCC	:	0.68
FCC	:	0.74
HCP	:	0.74

11. (c)

For the ideal HCP packing, the ratio of c/a is $\sqrt{\frac{8}{3}}$ i.e. 1.633. The actual HCP metals deviate from ideal c/a ratio.

12. (c)

The cubic closed pack structure is the structure in which the unit cell consists layers contains six atoms at the corners of a hexagon and one atom at the centre of each hexagon. FCC is cubic closed pack structure.

13. (b)

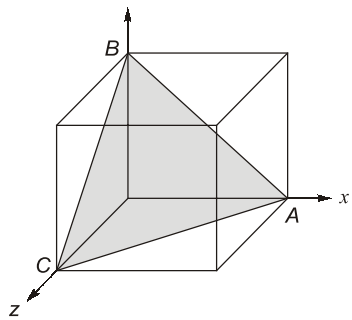
Phenomenon of cross-slip occurs in screw dislocation, in which burger vector is parallel to the dislocation line. Screw dislocations are so named because the atomic planes form a spiral ramp.

14. (c)

Elastic strain energy per unit length of a dislocation is directly proportional to the square of burger's vector '*b*'.

15. (b)

The miller indicates of the diagonal plane (*ABC*) of cube is (111).



16. (b)

Austenite is the solid solution of ferrite and iron carbide in gamma iron which is formed when steel contains carbon upto 1.8% at 1130°C temperature.

It is non-magnetic in nature and its crystal structure is FCC.

17. (b)

The crystallography is the experimental science of determining the arrangement of atoms in crystalline solids.
X-ray crystallography is used to determine the structure of metals.

18. (b)

Diamond cubic - Si, Ge, Grey - Tin

BCC – Li, Na, K, Mo, α – Fe, α – Cr, α – W, δ – Fe, β – Ti
FCC – Al, Cu, Ag, Au, γ – Fe, β – Co, β – Ni, etc
HCP – Mg, Zn, Cd, Ca, γ – Ti, Ba etc

19. (c)

- An edge dislocation's line is perpendicular to its Berger's vector.
- The movement of edge dislocation in the slip planes is in the direction of Berger's vector.
- The speed of movement is fast.
- The edge dislocation explains only plastic deformation.
- The shear stress required to produce edge dislocation are less.

20. (a)

In screw dislocation, burger's vector is parallel to screw dislocation line, and is formed when crystal displaces angularly over the remaining parts.

21. (a)

BCC – Li, Na, K, Mo, α-Fe, α-Cr. α-W, δ – Fe, δ –Ti
FCC – Al, Cu, Ag, Au, γ-Fe, β-Co, β-Ni
HCp – Mg, Zn, Cd, Ca, γ-Ti, Ba, etc
SC – α-Polonium

22. (b)

The stress energy for a dislocation of unit length can be written as $U = \frac{Gb^2}{2}$

where G = modulus of rigidity

23. (b)

Climb is a dislocation movement in which dislocation moves from one slip plane to another slip plane.

Where as Glide is a dislocation movement in which dislocation moves within the same slip plane.

24. (c)

(hkl) denotes plane
[hkl] denotes direction
{hkl} denotes family of planes
<hkl> denotes family of directions

25. (d)

- Point imperfection – Vacancy defect, Interstitial defect, Schottky defect, Frenkel defect
- Line imperfection – Dislocation
- Surface imperfection – Grain boundary, Twinning
- Volume imperfection – Pores

26. (c)

Dislocations are another type of defects in crystals. Dislocations are the areas where the atoms are out of the position in crystal structure. Dislocations are generated and move when a stress (shear) is applied.
The motion of dislocations allow slip-plastic deformation to occur in metals.

27. (b)

For simple cubic effective number of lattice point = 1
For B.C.C. effective number of lattice point = 2

For F.C.C. effective number of lattice point = 4

28. (b)

The intercept on z-axis is infinite . So taking reciprocal, it will be zero on z-axis. Thus the miller indices for the hatched plane will be (110).

29. (d)

Edge dislocation is line defect. Frankel and schottkey defect are both point defects.

Frankel & Schottkey defects are point defect. In frankel defect an atom in lattice occupies an interstitial void. In schottkey defect an anion and a cation are absent in lattice.

30. (d)

X-ray wavelength = λ
Reflection angle, $\theta = 8°$ for $n = 1$

Interplanar distance, $d = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$