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MATERIAL SCIENCE

MECHANICAL ENGINEERING

Date of Test : 27/03/2024

ANSWER KEY ➤

1.	(a)	7.	(d)	13.	(b)	19.	(a)	25.	(a)
2.	(c)	8.	(b)	14.	(b)	20.	(a)	26.	(c)
3.	(b)	9.	(c)	15.	(c)	21.	(c)	27.	(c)
4.	(a)	10.	(b)	16.	(c)	22.	(b)	28.	(b)
5.	(c)	11.	(b)	17.	(b)	23.	(c)	29.	(a)
6.	(d)	12.	(c)	18.	(d)	24.	(c)	30.	(d)

DETAILED EXPLANATIONS

4. (a)

Peritectic reaction:

Liquid A + Solid B → Solid C

5. (c)

Twin boundary is a special type of grain boundary across which there is specific mirror lattice symmetry. Twin boundaries occur in pairs such that the orientation change introduced by one boundary is restored by the other. The region between the pair of boundaries is called twinned region. Twinning occurs on a definite crystallographic plane and in a specific direction both of which depend on crystal structure.

6. (d)

- Ledeburite is formed at a temperature of 1150°C with carbon percentage of 4.3%.
- It has a plate like structure of austenite and Fe_3C.

$$\text{Liquid Iron} \xrightarrow[\text{On cooling}]{1150^\circ C,\ 4.3\%C} \gamma + Fe_3C$$

7. (d)

Elastic modulus of a material depends on the composition hence cannot be altered by heat treatment.

8. (b)

Annealing refers to a wide group of heat treatment process and is performed primarily for homogenisation, recrystallisation, or relief of residual stress in typical cold worked or welded components. During stress relief annealing process, workpiece is heated below its recrystallisation temperature, held for some time and then cooled in air.

10. (b)

Crystal System	Axial Ratio	Axial Angles
Cubic	a = b = c	$\alpha = \beta = \gamma = 90^\circ$
Rhombohedral	a = b = c	$\alpha = \beta = \gamma \neq 90^\circ$
Tetragonal	a = b ≠ c	$\alpha = \beta = \gamma = 90^\circ$
Hexagonal	a = b ≠ c	$\alpha = \beta = 90^\circ,\ \gamma = 120^\circ$
Orthorhombic	a ≠ b ≠ c	$\alpha = \beta = \gamma = 90^\circ$
Monoclinic	a ≠ b ≠ c	$\alpha = \gamma = 90^\circ \neq \beta$
Triclinic	a ≠ b ≠ c	$\alpha \neq \beta \neq \gamma \neq 90^\circ$

11. (b)

Interplaner spacing

d_{hkl} = 0.1013 nm

Order of reflection, n = 1

Wavelength, λ = 0.1790 nm

$$\sin\theta = \frac{n\lambda}{2d_{hkl}} = \frac{1 \times 0.1790}{2 \times 0.1013} = 0.884$$

$\Rightarrow \quad \theta = \sin^{-1}(0.8841) = 62.13°$

Diffraction angle $= 2\theta = 124.26°$

12. (c)

Let p, q, r be the intercepts on x, y and z axes respectively, then,

$$p : q : r = \frac{a}{h} : \frac{b}{k} : \frac{c}{l}$$

where a, b and c are primitives and h, k and l are miller indices.

Given: $a = 1.2$ Å $\quad b = 1.8$ Å

$c = 2$ Å $\quad h = 2$

$k = 3, \quad l = 1$

$$p : q : r = \frac{1.2}{2} : \frac{1.8}{3} : \frac{2}{1} = 0.6 : 0.6 : 2$$

$$p : q = 0.6 : 0.6 \quad \Rightarrow \quad 1.2 : q = 0.6 : 0.6$$

$$q = \frac{1.2 \times 0.6}{0.6} = 1.2 \text{ Å}$$

Similarly, $q : r = 0.6 : 2$

$1.2 : r = 0.6 : 2$

$$r = \frac{1.2 \times 2}{0.6} = 4 \text{ Å}$$

$$\therefore \quad \frac{q}{r} = \frac{1.2}{4} = 0.3$$

13. (b)

Length of the edge of unit cell= $l = 654$ pm $= 6.54 \times 10^{-8}$ cm

Volume $= V = l^3 = (6.54 \times 10^{-8})^3$ cm^3

Molecular mass of KBr $= 119$ g/mol

Density $= \rho = 2.75$ g/cm^3

$$\rho = \frac{n \times M}{V \times N_o}$$

$$\Rightarrow \quad n = \frac{\rho \times V \times N_o}{M}$$

$$\Rightarrow \quad n = \frac{2.75 \times \left(6.54 \times 10^{-8}\right)^3 \times \left(6.023 \times 10^{23}\right)}{119}$$

$\Rightarrow \quad n = 3.89 \simeq 4$ (Since number of atoms will be whole number)

15. (c)

Lattice parameter of FCC structure = a

Radius of an atom, $r = \frac{\sqrt{2}a}{4}$

Area of (1 0 0) plane $= a^2$

No. of atoms on (1 0 0) plane = 2

Area of 2 atoms $= 2\pi r^2$

$$= 2\pi \times \left(\frac{\sqrt{2}a}{4}\right)^2$$

$$= 0.785\ a^2$$

$$\text{Planar density} = \frac{0.785a^2}{a^2}$$

$$= 78.5\ \%$$

16. (c)

Addition of vanadium in steel increases the yield strength and the tensile strength. It also improves creep resistance and impact resistance due to formation of hard Vanadium Carbides.

18. (d)

Gibbs phase rule is given by

$F = C - P + 1$ (When pressure is kept constant)

Where,

C = Number of components

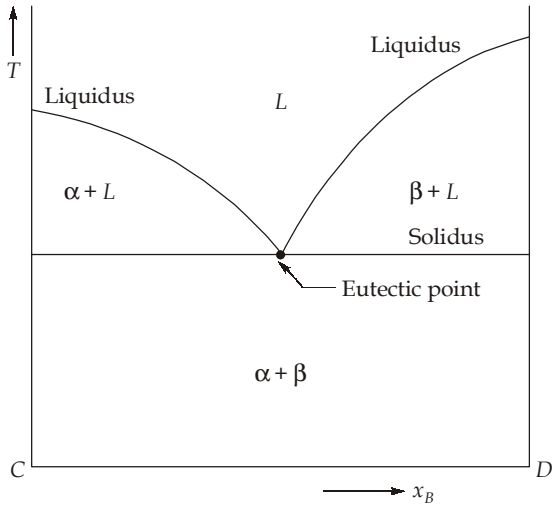
P = Number of phases

F = Degree of freedom

for binary phase diagram $C = 2$

$P = 3$ (as α, β and L coexist at eutectic point)

$\therefore$ $F = 0$ at eutectic point



Eutectic phase diagram between component C and D

19. (a)

- Copper, silver and gold have FCC structure.
- Cementite (Fe_3C) has an orthorhombic crystal structure and is extremely hard and brittle as compared to austenite and ferrite.

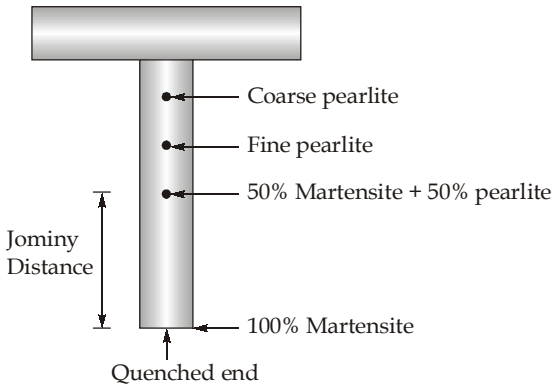
21. (c)

By Lever rule:

$$M_\alpha = \frac{99-40}{99-11} = \frac{59}{88}$$

$$= 67\%$$

22. (b)



23. (c)

There is no mushy zone for the composition C3 it has the highest fluidity.

24. (c)

Vacancy, Schottky → Point defects or zero dimensional defects

Edge dislocation → line defects or one dimensional defect

25. (a)

Pitting corrosion affects metals and alloys such as steel, Iron, Aluminium etc. It is usually constrained to specific areas. It penetrates and attacks rapidly that is why it is difficult to detect.

29. (a)

Trade names of super alloys are:

1. Wasp alloy
2. Inconel
3. Astrology
4. Incoloy
5. Nimonic

30. (d)

Electro deposition has liquid as its starting phase, while rest three have solid as starting phase.

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