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MATERIAL SCIENCE

MECHANICAL ENGINEERING

Date of Test : 15/07/2022

ANSWER KEY ➤

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

DETAILED EXPLANATIONS

1. **(c)**

If 'a' is the lattice parameter then
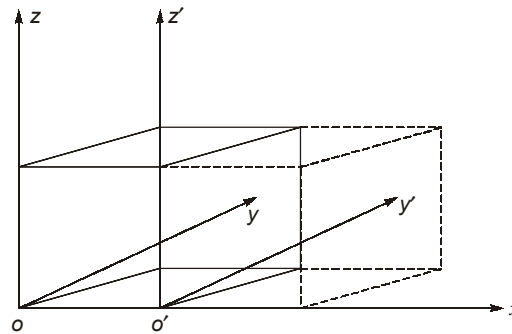
Atomic radius of BCC crystal, 'r' = $\dfrac{a\sqrt{3}}{4}$

atomic diameter = $2r = \dfrac{a\sqrt{3}}{2}$ or $\dfrac{a}{2/\sqrt{3}}$

2. **(c)**

Grain boundaries restricts the motion of dislocation. It makes the material stronger.

3. **(d)**

Since the plane passes through origin O, a new origin must be chosen at the corner of an adjacent unit cell, taken as o' and shown in diagram.

This plane is parallel to the z axis, and the intercept may be taken as ∞. The x and y axes intersections, referenced to the new origin o', are –1 and 1 respectively. The reciprocals of these numbers are –1, 1 and 0. So, miller indices of shown plane is $\left(\overline{1}\,1\,0\right)$.

4. **(a)**

For a direction indices [$u\,v\,w$] and a plane indices (h k l)
If $\qquad uh + vk + wl = 0$
Then both direction and plane are parallel to each other or direction lies in the given plane.

5. **(b)**

Cooling curve of a binary alloy may look exactly similar to that of a pure metal if it is an eutectic alloy.
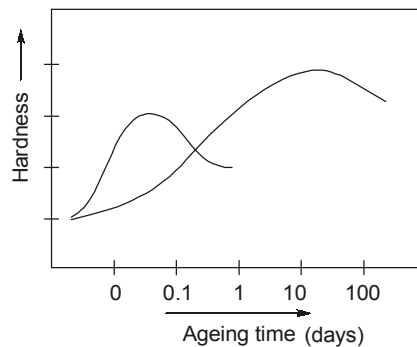
6. **(c)**

According to Hume-Rothery rules, it is not necessary condition that elements of the system should form compounds with each other.

7. **(a)**

The final structure of austempered steel will be bainite where as final structure of martempered steel will be martensite.

8. (d)

The increase in hardness in the initial stages of the ageing curves can be attributed to the precipitation process taking place progressively. After reaching the peak value, the hardness starts to decrease. This phenomena is called overageing.

9. (a)

Inconel is a family of austenitic nickel chromium based superalloys. They are oxidation and corrosion resistant materials well suited for service in extreme environments subjected to pressure and heat. It has composition about 75% Ni, 15% Cr and 9% Fe, and remaining percentage includes C, S, P, B, Ti etc.

10. (d)

11. (d)

Creep curve shows the increase in plastic strain as a function of time.
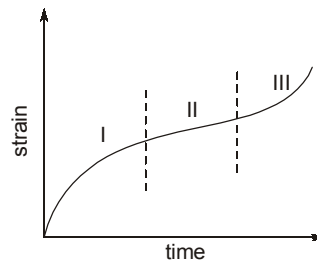
It consists of 3 stages:
- In stage I, creep rate decreases with time.
- In stage II, creep rate is minimum and constant with time.
- In stage III, creep rate increases with time until fracture occurs.

12. (b)

Pitting corrosion is a localized phenomenon confined to smaller areas. Formation of micropits can be very damaging. Pitting factor (ratio of deepest pit to average penetration) can be used to evaluate severity of pitting corrosion which usually occurs in passive metals and alloys.

13. (b)

At 900°C temperature carbon reacts with chromium to form chromium carbide when carbon diffuses to grain boundaries. This process depends upon temperature range and time.

14. (b)

Jominy end-quench test is carried out to determine hardenability of steel and not hardness.

15. (c)

Ceramics are hard and anti-static in nature.

16. (d)

In fiber reinforced composites last constituent to fail is matrix and first one is fiber.

17. (a)

Mechanically, gray cast iron is comparitively weak and brittle in tension whereas their strength and ductility is much higher under compressive loads.

18. (b)

19. (b)

- The iron-carbon diagram is plotted under equilibrium conditions and TTT curve is plotted under non-equilibrium conditions.
- The main purpose of spheroidising treatment is to improve machinability of high carbon steel.
- The martensitic transformation is a process of shear, that occurs without any need for diffusion so there will be no change in composition in this process.

20. (b)
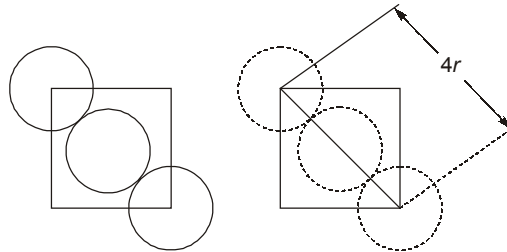
$$4r = \sqrt{2}a$$

$$\text{Packing factor} = \frac{4 \times \frac{4}{3}\pi r^3}{a^3}$$

$$\text{P.F.} = \frac{16\pi}{3}\frac{r^3}{\left(2\sqrt{2}r\right)^3} - \frac{16\pi}{3 \times 16\sqrt{2}} = \frac{\pi}{3\sqrt{2}} = 0.74$$

21. (b)

22. (b)

23. (d)

Angle between two intersecting directions $(h_1\, k_1\, l_1)$ and $(h_2\, k_2\, l_2)$ is given by,

$$\cos\theta = \frac{h_1 h_2 + k_1 k_2 + l_1 l_2}{\sqrt{h_1^2 + k_1^2 + l_1^2} \times \sqrt{h_2^2 + k_2^2 + l_2^2}}$$

So for directions [1 1 1] and [1 $\bar{2}$ 1]

$$\cos\theta = \frac{1\times 1 + 1\times(-2) + 1\times 1}{\left(\sqrt{1^2 + 1^2 + 1^2}\right)\left(\sqrt{1^2 + (-2)^2 + 1^2}\right)}$$

$$\cos\theta = 0$$

$$\theta = 90°$$

27. (a)

In binary phase diagrams pressure changes often produce no significant effect on the equilibrium and therefore it has been arbitrarily omitted and the phase rule for condensed phases is written in a modified form as

$$F = C - P + 1$$

28. (d)

According to lever rule, the fraction of solid phase is

$$x_s = \frac{C_L - C_0}{C_L - C_S} = \frac{72 - 48}{72 - 26} = 52\%$$

29. (a)

Lattice parameter of FCC structure be a

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

Area of face $= a^2$

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

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

$$= 0.785\, a^2$$

Planar density $= \dfrac{0.785 a^2}{a^2}$

$$= 78.5\ \%$$

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