CLASS TEST

S.No. : 01 SP_ME_A+C_240123

MADE EASY

India's Best Institute for IES, GATE & PSUs

Delhi | Bhopal | Hyderabad | Jaipur | Lucknow | Pune | Bhubaneswar | Kolkata

Web: www.madeeasy.in | **E-mail:** info@madeeasy.in | **Ph:** 011-45124612

MATERIAL SCIENCE

MECHANICAL ENGINEERING

Date of Test : 24/01/2023

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

2. (a)

- In nodular cast iron, graphite is in the form of spheroids.
- In malleable iron, carbon is present in the form of nodular aggregates of graphite.

3. (c)

There will be no change in density because of Frenkel defect. So density with the presence of Frenkel defect will be same as density of perfect crystal.

$$\rho_{\text{Frenkel}} = \rho_{\text{perfect}} = 2100.3 \text{ kg/m}^3$$

4. (c)

5. (b)

Carbon forms interstitial carbides with iron due to large difference in atomic radii.

6. (b)

$$\text{Void fraction} = 1 - \text{packing efficiency}$$
$$= 1 - 0.74 \text{ (for FCC)} = 0.26$$

7. (a)

Hypoeutectoid steels on cooling during annealing process converts to pearlite. It have coarse grain structure.

8. (b)

Wet corrosion is explained by mechanism of electrochemical reaction.

9. (d)

There are following functions of matrix phase:

1. Matrix binds the fibres together.
2. Matrix acts as a mechanism by which an external load is transmitted and distributed to the fibres.
3. Matrix protects the individual fibres from surface damage.
4. At the same time, matrix separates the fibres and prevents the propagation of brittle cracks.

10. (d)

Edge dislocations in crystal lattices introduce compressive, tensile, and shear lattice strains while screw dislocations only introduce shear strains

11. (a)

Carburizing is applied to low carbon steel upto 0.18% carbon. In carburizing the carbon content of the surface layer is increased, the purpose is to obtain a hard layer on the workpiece surface after heat treatment.

12. (c)

Buna-N is prepared by copolymerization of butadiene and acrylonitrile in emulsion system. Buna-N is nitrile rubber used in automotive and aeronautical industry to make fuel and oil handling hoses.

13. (b)

- LDPE has low rigidity and is not suitable for load bearing applications.
- LDPE is tough and flexible.

14. (b)

Size of atoms of each two elements must not differ by more than 15%.

15. (d)

16. (a)

- With decrease in grain size, the mean distance of a dislocation travel decreases, and soon starts pile up of dislocations at grain boundaries. This leads to increase in yield strength of the material.
- To initiate plastic deformation, polycrystalline metals require higher stresses than for equivalent single crystals where stress depends on orientation of the crystal.

17. (c)

18. (c)

Austenite sample is quenched at a rate greater than or equal to critical cooling rate to a temperature below the nose but above martensite start line. This temperature is maintained for substantial period of time so that transformation line enters into TTT curve. This produces bainite. Bainite cannot be produced by continuous cooling. This process of producing bainite is called austempering.

19. (c)

It is fastest case hardening process. Samples are passed through induction coil and heat will develop to the surface due to eddy current. Advantage of induction heating is that it can be localized. Samples are then immediately quenched into an oil bath to produce a thin layer of martensite over it.

20. (d)

Sample size = 100 gram

Mass of iron atoms = 99.99 gram

Mass of carbon atoms = 0.01 gram

Molecular weight of iron = 56 g/mol

Molecular weight of carbon = 12 g/mol

Avogadro's number, $N_A = 6.023 \times 10^{23}$ atoms/mol

$$\text{Number of iron atoms} = \frac{99.99}{56} \times 6.023 \times 10^{23} = 10.7542816 \times 10^{23} \text{ atoms}$$

$$\text{Number of carbon atoms} = \left(\frac{0.01}{12}\right) \times 6.023 \times 10^{23} = 5.0191667 \times 10^{20} \text{ atoms}$$

Number of iron atoms per unit cell of BCC structure = 2

Number of iron atoms in 10000 unit lattices = 20000 atoms

$$\text{Number of carbon atom} = 20000 \times \left(\frac{5.0191667 \times 10^{20}}{10.7542816 \times 10^{23}}\right) = 9.33426 \simeq 10$$

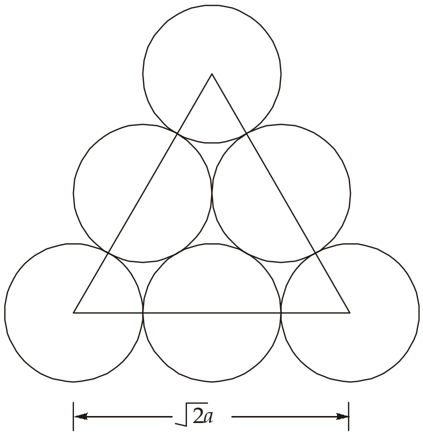
21. (a)

$$\text{Planar density}_{(1\,1\,0)} = \frac{2}{a^2\sqrt{2}} = \frac{\sqrt{2}}{a^2}$$

$$\text{Planar density}_{(1\,1\,1)} = \frac{2}{\left(\frac{\sqrt{3}}{4}\right)\times(\sqrt{2}a)^2} = \frac{4}{(\sqrt{3})a^2}$$

$$\text{Planar density}_{(1\,0\,0)} = \frac{2}{a^2}$$

In FCC crystal (1 1 1) plane is most densely packed plane.



22. (b)

If grains are coarse, creep strength is improved.

23. (a)

Given:

Weight % of α-phase, $W_\alpha = 66\%$

Weight % of β-phase, $W_\beta = 100 - 66 = 34\%$

Volume % of α-phase, $V_\alpha = 57.08\%$

Density of α-phase, $\rho_\alpha = 10.643 \text{ g/cm}^3$

We know that,

$$\text{Volume \% of α-phase, } V_\alpha = \frac{W_\alpha / \rho_\alpha}{\frac{W_\alpha}{\rho_\alpha} + \frac{W_\beta}{\rho_\beta}}$$

$$0.5708 = \frac{0.66 / 10.643}{\frac{0.66}{10.643} + \frac{0.34}{\rho_\beta}}$$

$$\frac{0.66}{10.643} + \frac{0.34}{\rho_\beta} = \frac{0.66}{10.643 \times 0.5708}$$

$$\frac{1}{\rho_\beta} = \frac{1}{0.34}\left[\left(\frac{0.66}{10.643 \times 0.5708}\right) - \left(\frac{0.66}{10.643}\right)\right] = 0.137144$$

Density of β-phase, $\rho_\beta = 7.2916 \approx 7.292 \text{ g/cm}^3$

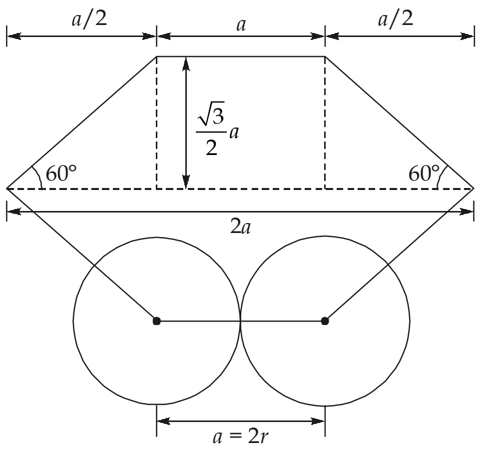
24. (d)

Number of atoms per unit cell = 6

Volume of unit cell, V_C = (Base area) × (Height)

$$= 2 \times \left[\frac{1}{2} \times (a + 2a)\frac{\sqrt{3}}{2}a\right] \times c$$

$$= \frac{3\sqrt{3}}{2}a^2 c$$



For HCP crystal, $a = 2r$

Let, $\frac{c}{a} = x$

$$c = xa = (2r)x$$

$$\text{APF} = \frac{n \times \left(\frac{4}{3}\pi r^3\right)}{V_C} = \frac{6 \times \left(\frac{4}{3}\pi r^3\right)}{\left(\frac{3\sqrt{3}}{2}\right)(xa^3)}$$

$$0.68 \times \left(\frac{3\sqrt{3}}{2}\right) \times \left[x \times (2r)^3\right] = 6 \times \frac{4}{3}\pi r^3$$

$$x = \frac{2 \times 24\pi r^3}{\left(9\sqrt{3} \times 8r^3\right) \times 0.68} = 1.7782$$

Now, $\frac{c}{a} = 1.778$

25. (a)

26. (a)

Volume fraction of fibre, $V_f = 0.4$

Volume fraction of polyester resin, $V_R = 1 - 0.4 = 0.6$

$$E_f = 70 \text{ GPa}$$
$$E_R = 3.5 \text{ GPa}$$

For longitudinal direction,

$$E_c = E_f V_f + E_R V_R$$
$$= 0.4 \times 70 + 0.6 \times 3.5 = 30.1 \text{ GPa}$$

27. (a)

28. (c)

29. (d)

Stress corrosion cracking takes place under the combined action of applied tensile stress and corrosive environment. Some materials, which are inert in a particular corrosive medium become susceptible when a tensile stress is applied. Small cracks are developed, which propagate in a direction perpendicular to tensile stress, resulting in eventual failure of material. Most alloys are susceptible to stress corrosion under specific environments. For example, stainless steels corrode in solution of chloride ions and brasses corrode when exposed to ammonia.

30. (b)

Crystal Structure	APF
SC	0.52
BCC	0.68
FCC	0.74
Diamond	0.34
HCP	0.74

■■■■