

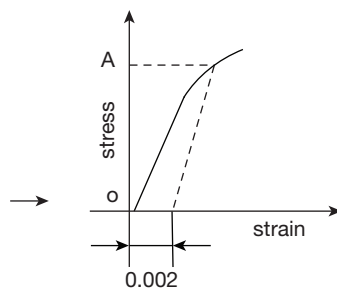
# ENGINEERING MATERIALS AND METROLOGY AND INSPECTION TEST 3

Number of Questions: 25

Time:60 min.

**Directions for questions 1 to 25:** Select the correct alternative from the given choices.

- Which of the ferrous alloy becomes completely liquid first on heating?  
(A) Cast iron  
(B) Medium– Carbon steel  
(C) Low – Carbon steel  
(D) High – Carbon steel
- The coordination number for a face centered cubic unit cell is  
(A) 6  
(B) 8  
(C) 12  
(D) 4
- The maximum wt% of carbon in  $\alpha$ -Fe is 0.022% and the eutectoid reaction occurs at 0.83 wt% of carbon. For an alloy with 0.45 wt% of carbon at a temperature just below the eutectoid what is the fraction of  $\text{Fe}_3\text{C}$  (Cementite) phase? (wt% of carbon in cementite is 6.7)  
(A) 58%  
(B) 6.4%  
(C) 5.6%  
(D) 64%
- Which of the processes involves heating of steel to Asutemite temperature?  
(A) High temperature Tempering  
(B) Full Annealing  
(C) Process Annealing  
(D) Low temperature Tempering
- The process of quenching the steels in water, oil or salt baths after heating and holding them to austenite temperature is known as  
(A) Diffusion traducing  
(B) Normalizing  
(C) Annealing  
(D) Hardening
- For a ductile material the point A is given as



- (A) Proportionality limit  
(B) Yeild strength  
(C) Fracture strength  
(D) Ultimate tensile strength
- In tensile test of a brass specimen, the strain is 0.0016 for a stress of 152 MPa. The modulus of elasticity of the specimen is  
(A) 97 GPa  
(B) 95 GPa  
(C) 94 GPa  
(D) 93 GPa

- The units of modulus of resilience is  
(A) J/s  
(B)  $\text{J.m}^3$   
(C)  $\text{J/m}^3$   
(D) J.s
- The maximum clearance possible for the shaft and hole of size  $40^{+0.05}_{-0.02}$  mm and  $40^{+0.03}_{-0.04}$  mm is  
(A) 0.09 mm  
(B) 0.02 mm  
(C) 0.03 mm  
(D) 0.05 mm
- What is the tolerance of the shaft of dimension  $50^{+0.008}_{-0.045}$  mm  
(A) 0.053 mm  
(B) 0.045 mm  
(C) 0.037 mm  
(D) 0.008 mm

11. Match List I with List II

| List I |                    | List II |      |
|--------|--------------------|---------|------|
| P      | Lattice parameters | 1.      | 0.74 |
| Q      | APF of FCC         | 2.      | 7    |
| R      | Crystal systems    | 3.      | 0.68 |
| S      | APF of BCC         | 4.      | 6    |

APF = atomic packing factor

- |     |   |   |   |   |
|-----|---|---|---|---|
|     | P | Q | R | S |
| (A) | 4 | 3 | 2 | 1 |
| (B) | 2 | 3 | 4 | 1 |
| (C) | 4 | 1 | 2 | 3 |
| (D) | 2 | 1 | 4 | 3 |
12. Match List I with List II (Phases of Fe)

| List I |           | List II |                                |
|--------|-----------|---------|--------------------------------|
| K      | Pearlite  | 1.      | $\alpha$                       |
| L      | Cementite | 2.      | $\delta$                       |
| M      | Ferrite   | 3.      | $\alpha + \text{Fe}_3\text{C}$ |
| N      | Austenite | 4.      | $\text{Fe}_3\text{C}$          |

- |     |   |   |   |   |
|-----|---|---|---|---|
|     | K | L | M | N |
| (A) | 4 | 3 | 2 | 1 |
| (B) | 3 | 4 | 1 | 2 |
| (C) | 3 | 4 | 2 | 1 |
| (D) | 4 | 3 | 1 | 2 |
- On cooling Austenite from  $1000^\circ\text{C}$  to  $600^\circ\text{C}$ , at what weight composition of carbon the phase changes to pearlite completely?  
(A) 0.022 wt% of C  
(B) 0.46 wt% of C  
(C) 0.83 wt% of C  
(D) 4.3 wt% of C
  - What is the volume of Fe - atoms (in  $\text{mm}^3$ ) in one unit cell of Austenite ( $\delta$  Fe)? (Take radius of Fe - atom as  $126 \times 10^{-12}$  m)  
(A)  $3.3156 \times 10^{-29}$   
(B)  $3.3516 \times 10^{-20}$   
(C)  $3.3516 \times 10^{-36}$   
(D)  $3.3516 \times 10^{-27}$

15. For the given four heat treatment processes, what is the ascending order according to the temperatures involved for steel?  
 (P) Full Annealing  
 (Q) Normalizing  
 (R) Process Annealing  
 (S) Low temperature Tempering  
 (A)  $P-Q-R-S$  (B)  $S-R-Q-P$   
 (C)  $S-R-P-Q$  (D)  $P-R-Q-S$
16. In full annealing process, the steel is heated from 50°C to 75°C above the upper critical temperature for which type of steels?  
 (L) Hypo – eutectoid steels  
 (M) Hyper – eutectoid steels  
 (A) Only  $L$  (B) Only  $M$   
 (C) Both  $L$  and  $M$  (D) None of these
17. Which of these is NOT a case hardening process for steels?  
 (A) Nitriding (B) Cyaniding  
 (C) Carburizing (D) Tempering
18. The reaction which does NOT appear on the Fe – Fe<sub>3</sub>C diagram is ( $L$  – Liquid,  $S$  – Solid)  
 (A)  $L S_1 + S_2$  (B)  $L + S_1 S_2$   
 (C)  $S_1 S_2 + S_3$  (D)  $S_1 + S_2 S_3$
19. The gauge length and fracture length of a titanium specimen are 120 mm and 150 mm respectively in a tension test. What is the ductility of the specimen in percent elongation?  
 (A) 40 (B) 20  
 (C) 25 (D) 50
20. What is the change in length of a specimen having true strain as 0.095 for an initial length of 100 mm?  
 (A) 9.966 mm (B) 9.5 mm  
 (C) 10.99 mm (D) 109.96 mm
21. A steel rod, of 10 mm diameter is pulled longitudinally and the change in length is found to be 5 mm. If the initial length of the rod is 50 mm, then what is the final diameter of the rod?  
 (Take Poissons ratio of steel as 0.3)  
 (A) 9.97 mm (B) 10.03 mm  
 (C) 10.3 mm (D) 9.7 mm
22. The eutectoid reaction occurs at 0.83 wt% of carbon and at 723°C. If maximum wt% of carbon in  $\alpha$  – Fe is 0.02% and that of Fe<sub>3</sub>C is 6.67% then what is the mass fraction of  $\alpha$  – Fe in Pearlite?  
 (A) 87.82% (B) 12.18%  
 (C) 13.87% (D) 82.83%
23. In a hole base system, the size of hole is  $20^{+0.04}_{-0.00}$  and the shaft size is  $20^{+0.05}_{-0.00}$ . Then the fit possible is?  
 (A) Clearance fit (B) Transition fit  
 (C) Interference fit (D) None of these
24. The clearance of an interference fit is  
 (A) Positive (B) Negative  
 (C) Positive or Negative (D) Zero
25. A GO and NO-GO plug gauge is designed for a hole of  $30^{+0.05}_{-0.05}$  mm with a guage tolerance equal to 20% of the hole tolerance. The GO size of the gauge is  
 (A) 30.07 mm (B) 30.03 mm  
 (C) 29.93 mm (D) 29.97 mm

### ANSWER KEYS

- |       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1. A  | 2. C  | 3. B  | 4. B  | 5. D  | 6. B  | 7. B  | 8. C  | 9. A  | 10. C |
| 11. C | 12. B | 13. C | 14. B | 15. C | 16. A | 17. D | 18. D | 19. C | 20. A |
| 21. D | 22. A | 23. B | 24. B | 25. D |       |       |       |       |       |

### HINTS AND EXPLANATIONS

1. Most of the cast irons contain 3.0 to 4.5 wt% of C. The iron-iron carbide phase diagram reveals that alloys within this combination melt approximately between the temperatures 1150 to 1300°C which is less than that of steels. Ans (A)
2. In metals, every atom has same number of nearest neighbour atoms, which is the coordination number. In FCC, the coordination number is 12. Ans (C)
3.  $W_{Fe_3C} = \frac{C - 0.022}{6.7 - 0.022}$   $C = 0.45$   
 $\therefore W_{Fe_3C} = \frac{0.45 - 0.022}{6.7 - 0.022} = 0.064 = 6.4$  Ans (B)
4. Choice (B)
5. Choice (D)
6. Choice (B)

$$7. E = \frac{\Delta\sigma}{\Delta\epsilon} = \frac{152 \times 10^6}{0.0016} = 95 \times 10^9 \text{ Pa} = 95 \text{ GPa} \text{ Ans (B)}$$

$$8. \text{Modulus of resilience} = U_r = \frac{1}{2} \sigma_y \cdot \epsilon_y$$

The units are J/m<sup>3</sup> i.e. Pa Ans (C)

$$9. \text{Maximum clearance} = \text{Max.size of hole} - \text{Min.size of shaft} \\ = 40.05 - 39.96 = 0.09 \text{ mm} \text{ Ans (A)}$$

$$10. \text{Tolerance} = \text{Upper diameter of shaft} - \text{Lower diameter of shaft} \\ = (50 - 0.008) - (50 - 0.045) = 0.037 \text{ mm} \text{ Ans (C)}$$

11. Choice (C)

12. Choice (B)

13. The eutectoid composition of ferrite and cementite is referred to as pearlite.

The eutectoid reaction occurs at 0.83 wt% of C.



14.  $\delta$ -Fe has FCC crystal structure

$\therefore$  Number of Fe-atoms per unit cell

$$= \left(6 \times \frac{1}{2}\right) + \left(8 \times \frac{1}{8}\right) = 3 + 1 = 4$$

i.e., 6 face atoms and 8 corner atoms

$\therefore$  Volume of Fe - atoms in single unit cell =

$$4 \times \left(\frac{4}{3} \pi r^3\right)$$

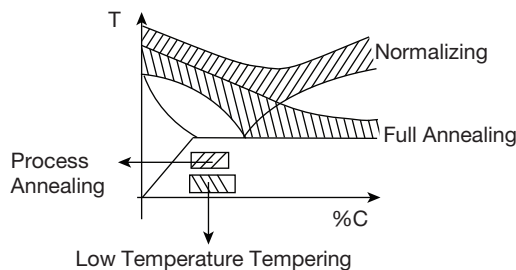
$$r = 126 \times 10^{-12} \text{ m}$$

$$\therefore \text{Volume} = 4 \times \frac{4}{3} \times \pi \times 126^3 \times 10^{-36}$$

$$= 3.3516 \times 10^{-29} \text{ m}^3 = 3.3516 \times 10^{-29} \times 10^9 \text{ mm}^3$$

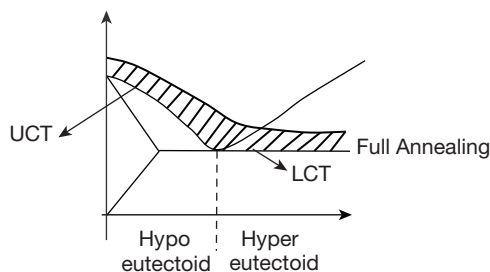
$$= 3.3516 \times 10^{-20} \text{ mm}^3 \text{ Ans (B)}$$

15.



Ans (C)

16.



In hypo-eutectoid steels, the full annealing takes place at a temperature of 50–75°C above the upper critical temperature whereas in hyper-eutectoid steels it is about the lower critical temperature. Ans (A)

17. • In Nitriding, Nitrogen content of the surface is increased.

• In Cyaniding, NaCN is used to produce a thin surface of high hardness

• In Carburizing, the carbon content of the surface layer is increased

• Tempering is done to relieve the residual stresses and improve ductility and toughness. Ans (D)

18.  $L S_1 + S_2$  – Eutectic reaction

$L + S_1 S_2$  – Peritectic reaction

$S_1 S_2 + S_3$  – Eutectoid reaction

Ans (D)

19.  $L_0 = 120 \text{ mm}$ ,  $L_f = 150 \text{ mm}$

$$\% \text{ Elongation} = \frac{L_f - L_0}{L_0} \times 100 = \frac{150 - 120}{120} \times 100$$

$$= \frac{30}{120} \times 100 = 25\% \text{ Ans (C)}$$

20.  $L_0 = 100 \text{ mm}$ ,  $\epsilon_T = 0.095$

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

$$\Rightarrow \epsilon = 0.09966$$

$$\therefore \epsilon = \frac{\Delta L}{L_0} \Rightarrow \Delta L = 100 \times 0.09966$$

$$= 9.966 \text{ mm} \text{ Ans (A)}$$

21.  $L_0 = 50 \text{ mm}$ ,  $\Delta L = 5 \text{ mm}$ ,  $d_0 = 10 \text{ mm}$ ;  $\vartheta = 0.3$

$$\vartheta = \frac{-\epsilon_d}{\epsilon_L} = \frac{\text{Lateral strain}}{\text{Longitudinal strain}}$$

$$\therefore 0.3 = \frac{-\epsilon_d}{\frac{5}{50}}$$

$$\Rightarrow \epsilon_d = -0.03$$

$$\therefore \frac{d_i - d_0}{d_0} = \frac{d_i - 10}{10}$$

$$= -0.03 \Rightarrow d_i = 9.7 \text{ mm} \text{ Ans (D)}$$

22. Complete pearlite is formed at the eutectoid point

$$\therefore M_\alpha = \frac{6.67 - 0.83}{6.67 - 0.02} = 0.8782$$

$$\therefore M_\alpha = 87.82\% \text{ Ans (A)}$$

23. Maximum clearance = Max.size of hole – Min.size of shaft

$$= 20.04 - 20 = 0.04 \text{ mm (+ve)}$$

Minimum Interference = Min.size of hole – Max.size of shaft

$$= 20 - 20.05 = -0.05 \text{ mm}$$

- ∴ For some values there is clearance and for some values there is interference  
 ∴ The fit is a transition fit Ans (B)
- 24.** Min.clearance = Min.hole size – Max.shaft size  
 For interference fit Min. hole size < Max.shaft size  
 ∴ Clearance is negative. Ans (B)
- 25.** Tolerance of hole =  $30.05 - 29.95 = 0.1 \text{ mm}$   
 Gauge tolerance =  $\frac{20}{100} \times 0.1 = 0.02 \text{ mm}$   
 ∴ Go size = Minimum hole dia + Gauge tolerance  
 =  $29.95 + 0.02 = 29.97 \text{ mm}$  Ans (D)