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MATERIAL SCIENCE

MECHANICAL ENGINEERING

Date of Test : 19/01/2025

ANSWER KEY ➤

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

DETAILED EXPLANATIONS

1. (a)

Trade names of super alloys are:

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

2. (c)

Schottky defects in ceramic material occurs because of vacancies created by nearby pair of cation and anion.

Frankel defect in material occurs when an atom displaces from its regular position to interstitial void.

3. (b)

Angle between two intersecting directions

$$\cos\theta = \frac{h_1h_2 + k_1k_2 + l_1l_2}{\sqrt{h_1^2 + k_1^2 + l_1^2} \times \sqrt{h_2^2 + k_2^2 + l_2^2}}$$

$$\cos\theta = \frac{2\times 2 + 1\times 0 + 0\times(-1)}{\sqrt{2^2 + 1^2 + 0^2} \times \sqrt{2^2 + 0^2 + 1^2}} = \frac{4}{5}$$

$$\theta = 36.786 \approx 37^\circ$$

4. (d)

5. (d)

In austempering, the material is quickly quenched a little above the M_S temperature, to just miss the nose of cooling curve. It is maintained at the same temperature for a prolonged period, so that austenite would be transformed to bainite (very fine pearlite) under isothermal conditions. This temperature is selected based on the desirable final hardness.

6. (d)

Stacking faults are line as well as planar type of crystal imperfections.

7. (d)

Clearly from diagram, lattica parameter,

$$C = 2\ \text{Å},\ a = 1\ \text{Å},\ b = 1.5\ \text{Å}$$

So, for miller index of plane

	x	y	z
Fractional intercept =	$\frac{\frac{1}{2}\text{Å}}{1\ \text{Å}}$	$\frac{\frac{3}{4}\text{Å}}{1.5\ \text{Å}}$	$\frac{2\text{Å}}{2\ \text{Å}}$
=	$\frac{1}{2}$	$\frac{1}{2}$	1
Reciprocal of intercept =	2	2	1

Miler indices = (2 2 1)

8. (b)

9. (c)

As we know eutectoid composition is 0.8% C. From given 63% pearlite condition percentage of carbon is 0.5% and for coarse-grain structure: high temperature (1200°C) austenitizing and slow cooling (furnace) cooling is done.

10. (c)

Test Method	Tested properties
Spiral test	Fluidity
Cupping test	Formability
Knoop test	Micro hardness
Charpy test	Toughness or impact strength

11. (d)

Jominy End Quench test is the measurement technique use to measure hardenability.

12. (b)

The extent of coring increases with increasing separation between liquidus and solidus i.e in alloy with a wide freezing range . Upon fast cooling , the chance of cored structure in material increases.

13. (b)

- Martensite transformation is diffusionless and athermal.
- Hardness of martensite mainly depends on percentage carbon only and very slightly depends on alloying element.
- With increase percentage carbon in austenite M_s, M_f temperature both decreases.

14. (c)

Killed steel contains more than 0.25% of carbon.

15. (c)

Silver has FCC crystal structure.

16. (c)

After ageing when the sample is reloaded the yield point phenomena reappear because of diffusion of C or N at the dislocation site.

This phenomena does not appear in medium or high carbon steels.

17. (c)

Nimonic 90 alloy is a creep resisting alloy

C - 0.08% Co - 16%

Cr - 20% Ti - 2.3%

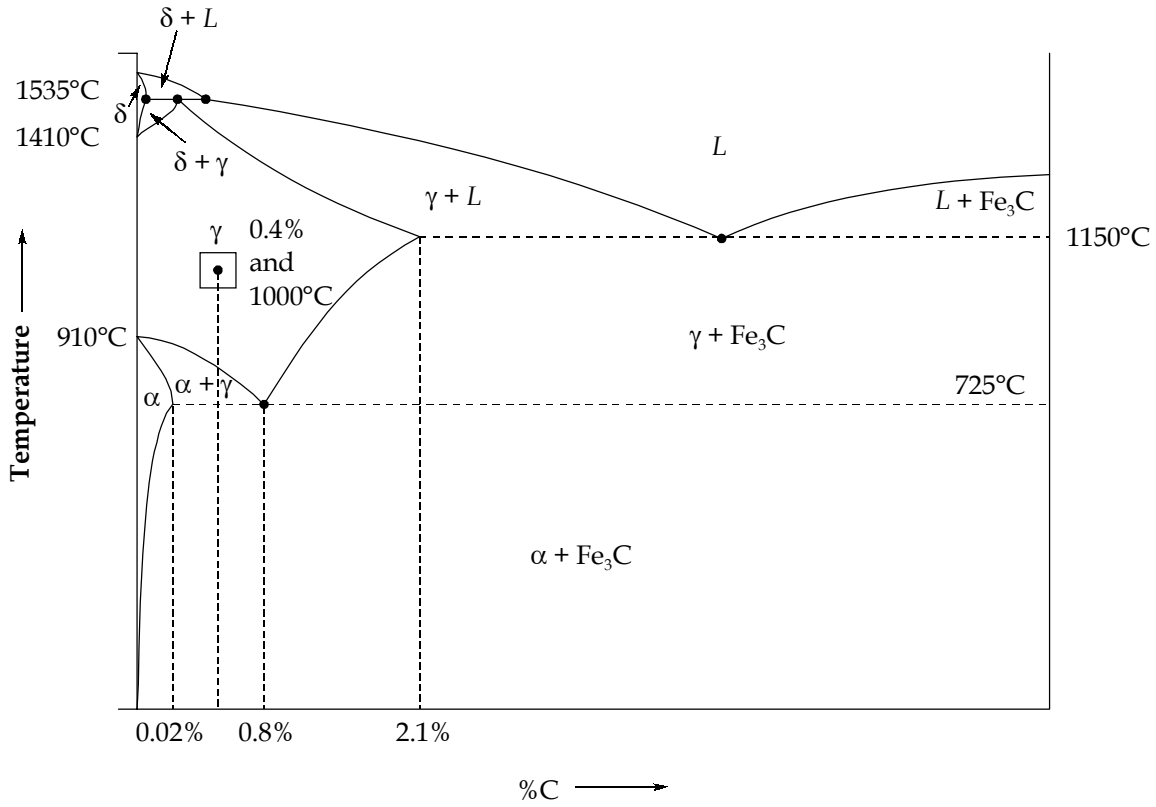
Ni - 58%

18. (d)

Diffusion of copper in nickel occurs by substitutional diffusion because of nearly same size of Cu and Ni.

19. (b)

At 1000°C and 0.4%C, the microstructure in Fe-C diagram will be of austenite.



20. (a)

Feldspar is basically used in ceramics to provide better binding tendency.

21. (b)

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

22. (d)

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

23. (d)

For Nano substances both sticking and friction are considerable properties.

24. (c)

High density polyethylene (HDPE) is a linear polymer.

25. (c)

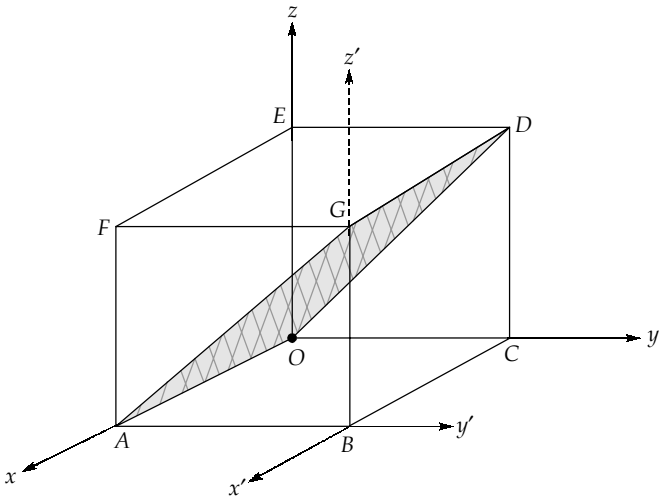
Sulphur is impurity in steel which is removed by adding (Mn) Manganese in steel. Mn makes 'MnS' reacting with sulphur.

26. (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.

27. (c)

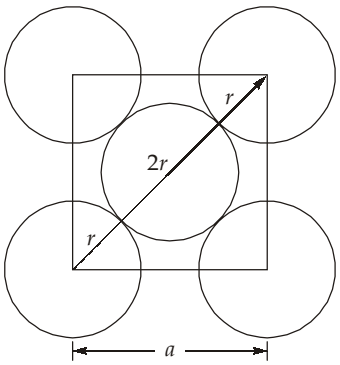
As plane passes through origin, with new origin at B:



	x	y	z
Intercept:	∞	–1	1
Reciprocal:	0	–1	1
Miller indices:	$(0\,\bar{1}\,1)$		

28. (b)

2 atoms will appear along that direction and the length of direction is $a\sqrt{2}$.



$$\text{Linear density} = \frac{\text{No. of atoms centered on direction vector}}{\text{Length of direction vector}}$$

$$= \frac{2 \text{ atoms}}{\sqrt{2}a} = \frac{2}{\sqrt{2}a} = \frac{4}{2\sqrt{2}a}$$

29. (b)

$$\sigma_o = 400 \text{ MPa}$$

$$\in = 0.35$$

So, $$\in_t = \ln(1 + \in) = \ln(1 + 0.35) = 0.3$$

$$\sigma_t = \sigma_o (1 + \in) = 400(1.35) = 540 \text{ MPa}$$

At UTS, $$n = \in_t = 0.3$$

$$\sigma_t = k \in_t^n$$

$$540 = k(0.3)^{0.3}$$

$$k = 775$$

So, power law equation is

$$\sigma_T = 775 \in_T^{0.3}$$

30. (a)

- Quenching of austenite yields martensite structure.
- Normalizing results in the formation of ferrite, cementite and lamellar pearlite.
- Austempering result in bainite formation.

■■■■