CLASS TEST

S.No.: 01_JP_ME_17072026

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MATERIAL SCIENCE + METAL CUTTING

MECHANICAL ENGINEERING

Date of Test : 17/07/2026

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (a)

Optimum tool life for maximum production rate is

$$T_{opt} = \frac{t_c(1-n)}{n} = \frac{2\times(1-0.25)}{0.25} = 6 \text{ minutes}$$

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)

For minimum shear strain, $2\phi - \alpha = 90°$

$$\phi = \frac{90° + \alpha}{2} = \frac{90° + 10°}{2} = 50°$$

$$\text{Shear strain} = \cot\phi + \tan(\phi - \alpha) = \cot 50° + \tan 40°$$

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. (c)

Effects of increasing positive rake angle:

- increase in tool life
- reduction in tool strength
- reduction in cutting force
- less heat generation

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)

For ORS system tool signature is

i - α - γ - γ_1 - C_e - λ - R

So, $\lambda = 90°$

As it is a turning operation, $t = f \sin\lambda = f\sin 90° = f$

12. (c)

Given: $\alpha_s = 10°$, $\alpha_b = 5°$, $\psi_s = 10°$, $\psi_e = 20°$

$$\tan\alpha = \tan\alpha_s \sin\lambda + \tan\alpha_b \cos\lambda$$

$$\text{Approach angle } (\lambda) = 90° - \psi_s = 90° - 10° = 80°$$

$$\tan\alpha = \tan 10° \sin 80° + \tan 5° \cos 80°$$

$$\alpha = 10.693° \simeq 10.7°$$

13. (c)

$$t_1 = 0.25 \text{ mm}$$

$$t_2 = 0.75 \text{ mm}$$

$$r = \frac{t_1}{t_2} = \frac{0.25}{0.75} = 0.33$$

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha} = \frac{0.33\cos 30°}{1 - 0.33\sin 30°}$$

$$\tan\phi = 0.346$$

14. (b)

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

15. (d)

The energy consumption per unit volume of material removal is commonly known as specific energy.

$$\text{Cutting force} = 2 \times 1000 \times 0.2 \times 2 = 800 \text{ N}$$

16. (c)

17. (c)

18. (b)

$$\alpha_1 = 4° = \frac{4\pi}{180} = 0.0698 \text{ radian}$$

$$\alpha_2 = 15° = \frac{15\pi}{180} = 0.2618 \text{ radian}$$

$$h_1 = e^{0.3[(\pi/2) - 0.0698]} = 1.5688$$

$$\text{Chip thickness ratio } (r_1) = \frac{1}{h_1} = \frac{1}{1.5688} = 0.6374$$

$$h_2 = e^{0.3[(\pi/2)-0.2618]} = 1.4809$$

$$\text{Chip thickness ratio } (r_2) = \frac{1}{h_2} = \frac{1}{1.4809} = 0.6753$$

$$\%\text{ change in chip thickness ratio} = \frac{r_2 - r_1}{r_1} \times 100\% = \left(\frac{0.6753}{0.6374} - 1\right) \times 100 = 5.95\ \%$$

19. (d)

Given, $\alpha = 10°$, $r = 0.4$

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha} = \frac{0.4\cos 10°}{(1 - 0.4\sin 10°)}$$

$$\phi = 22.94°$$

Now applying Merchant theory,

$$\phi = 45° + \frac{\alpha}{2} - \frac{\beta}{2}$$

$$22.94° = 45° + \frac{10°}{2} - \frac{\beta}{2}$$

$$\beta = 54.12°$$

$$\mu = \tan\beta = \tan 54.12° = 1.38$$

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

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

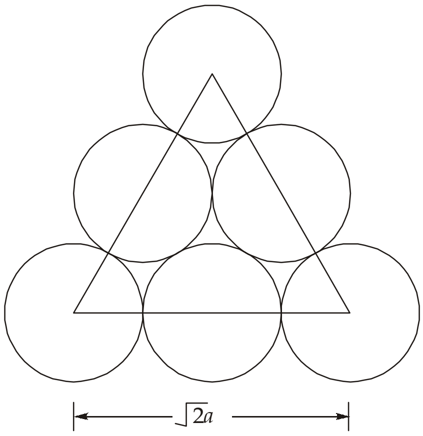
21. (a)

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

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

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

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



(1 1 1)plane

22. (b)

If grains are coarse, creep strength is improved.

23. (a)

Given:

Weight % of α-phase, W_α = 66%

Weight % of β-phase, W_β = 100 – 66 = 34%

Volume % of α-phase, V_α = 57.08%

Density of α-phase, ρ_α = 10.643 g/cm^3

We know that,

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

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

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

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

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

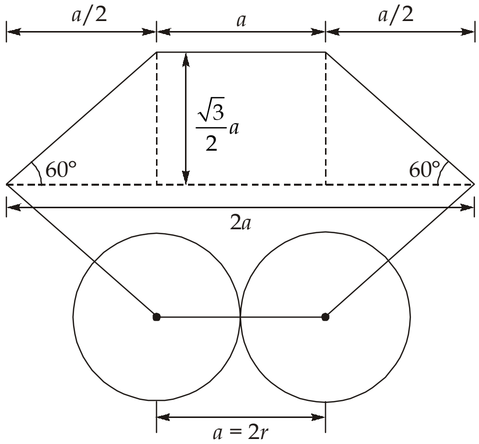
24. (d)

Number of atoms per unit cell = 6

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

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

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



For HCP crystal, $a = 2r$

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

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

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

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

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

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,

$$E_c = E_fV_f + E_RV_R$$

$$= 0.4\times 70 + 0.6\times 3.5 = 30.1 \text{ GPa}$$

27. (a)

28. (c)

29. (b)

Friction force, $F = F_C \sin\alpha + F_T \cos\alpha$

$= 1000 \sin(-5) + 500 \cos(-5) = 410.94 \text{ N} \simeq 411 \text{ N}$

30. (d)

$$V_2 T_2^{0.25} = V_1 T_1^{0.25}$$

$$\left(\frac{V_1}{2}\right) T_2^{0.25} = V_1 T_1^{0.25}$$

or $$\left(\frac{T_2}{T_1}\right)^{0.25} = 2$$

or $$\left(\frac{T_2}{T_1}\right) = 2^4 = 16$$

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