CLASS TEST

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S.No. : 05 GH1_ME_GS_240819

Material Science

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CLASS TEST 2019-2020

MECHANICAL ENGINEERING

Date of Test : 24/08/2019

ANSWER KEY ➤ Material Science

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

Detailed Explanations

1. (b)

$$\sqrt{3}a = 4r \rightarrow \text{BCC}$$
$$\sqrt{2}a = 4r \rightarrow \text{FCC}$$
$$a = 2r \rightarrow \text{HCP}$$

3. (c)

Silicon is used for promoting graphitization in cast iron.

4. (a)

Tungsten $\rightarrow$ BCC structure
Atomic packing factor = 0.68

5. (b)

7 – Crystal systems
14 – Bravais lattices

6. (c)

Cold working – when material is deformed below its recrystallization temperature.

8. (a)

Peritectic reaction : Liquid A + Solid $B \rightarrow$ Solid C.

9. (c)

$$\text{Atomic packing factor} = \frac{\text{Volume of atoms in a unit cell}}{\text{Volume of unit cell}}$$

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

$$\therefore \quad r = \left(\frac{a}{2\sqrt{2}}\right) \quad \text{....(1)}$$

$$= \frac{4 \times \frac{4}{3}\pi\left(\frac{a}{2\sqrt{2}}\right)^3}{a^3} = 0.74$$

10. (b)

$$\text{Body centered cubic} = \frac{1}{8} \times 8 + 1 = 2$$

13. (b)

$$n_{HCP} = 6$$
$$n_{DC} = 8$$
$$\frac{n_{HCP}}{n_{DC}} = \frac{6}{8} = 0.75$$

17. (d)

Length of the edge of unit cell, $l = 654 \text{ pm} = 6.54 \times 10^{-8}$ cm

Volume, $V = l^3 = (6.54 \times 10^{-8})^3 \text{ cm}^3$

Molecular mass of KBr = 119 g/mol

Density, $\rho = 2.75 \text{ g/cm}^3$

$$\rho = \frac{n \times M}{V \times N_A}$$

$$\Rightarrow \quad n = \frac{\rho \times V \times N_A}{M}$$

$$\Rightarrow \quad n = \frac{2.75 \times (6.54)^3 \times 10^{-24} \times (6.023) \times 10^{23}}{119}$$

$\Rightarrow \quad n = 3.89 \simeq 4$ (Since number of atoms will be whole number)

19. (a)

$$\sigma = k\varepsilon^n$$

$$\sigma = 800\varepsilon^{0.3}$$

at UTS, $n = \varepsilon$

$$\sigma = 800(0.3)^{0.3}$$

$$= 557.476 \text{ MPa} \quad ...(1)$$

and $\sigma = \sigma_0(1 + e)$ ...(2)

σ_0 = Ultimate tensile strength, e = engineering strain

$$\varepsilon = \ln(1 + e)$$

$$1 + e = e^{\varepsilon} = e^{0.3} = 1.349$$

From Eqs. (1) and (2), we get

$$557.476 = \sigma_o(1.349)$$

$$\sigma_o = 413.25 \text{ MPa}$$

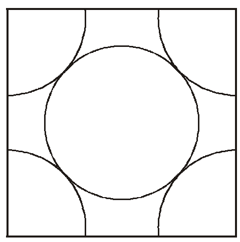
20. (a)

$$BHN = \frac{2P}{\pi D\left[D - \sqrt{D^2 - d^2}\right]} = \frac{2 \times 500}{\pi \times 10\left[10 - \sqrt{10^2 - 1.64^2}\right]}$$

$$= 235$$

22. (b)

FCC (100) plane



$$\text{Number of atoms} = \frac{1}{4} \times 4 + 1 = 2$$

$$\text{Area} = a \times a = a^2$$

$$\therefore \quad \text{Planar density} = \left(\frac{2}{a^2}\right)$$

$$\Rightarrow \quad x = 2$$

23. (c)

Muntz metal - Cu and Zn

Inconel - Cr, Ni and Fe

Monel - Ni and Cu

Invar - Ni and Fe

24. (c)

$$E_c = 0.2(300) + (1 - 0.2)100$$
$$= 60 + 80 = 140 \text{ GPa}$$

$$\text{Load fraction, } \frac{P_f}{P_m} = \frac{0.2(300)}{0.8(100)} = 0.75$$

26. (b)

Interplaner spacing

$$d_{hkl} = 0.1013 \text{ nm}$$
$$\text{Order of reflection, } n = 1$$
$$\text{Wavelength, } \lambda = 0.1790 \text{ nm}$$

$$\sin\theta = \frac{n\lambda}{2d_{hkl}} = \frac{1 \times 0.1790}{2 \times 0.1013} = 0.884$$

$$\Rightarrow \quad \theta = \sin^{-1}(0.8841) = 62.13°$$
$$\text{Diffraction angle} = 2\theta = 124.26°$$

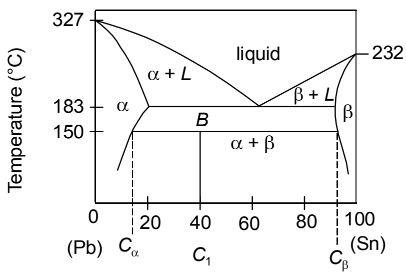
27. (b)

$$N_v = N \times e^{\left(\frac{-Q_v}{kT}\right)}$$
$$N = 8 \times 10^{28} \text{ atoms/m}^3$$
$$Q_v = 0.9 \text{ eV}$$
$$k = 8.62 \times 10^{-5} \text{ eV/K}$$
$$T = 1000 + 273 = 1273 \text{ K}$$

Putting the values,

$$N_v = 2.2 \times 10^{25} \text{ vacancies/m}^3$$

28. (b)



Composition of β-phase is tin nearly 98% and lead 2% at 150°C.

29. (a)

Let p, q, r be the intercepts on x, y and z axes respectively, then,

$$p : q : r = \frac{a}{h} : \frac{b}{k} : \frac{c}{l}$$

where a, b and c are primitives and h, k and l are miller indices.

Given:
$$a = 1.2 \text{ Å}$$
$$b = 1.8 \text{ Å}$$
$$c = 2 \text{ Å}$$
$$h = 2$$
$$k = 3, l = 1$$

$$p : q : r = \frac{1.2}{2} : \frac{1.8}{3} : \frac{2}{1} = 0.6 : 0.6 : 2$$
$$p : q = 0.6 : 0.6$$
$$\Rightarrow \quad 1.2 : q = 0.6 : 0.6$$
$$q = \frac{1.2 \times 0.6}{0.6} = 1.2 \text{ Å}$$

Similarly,
$$q : r = 0.6 : 2$$
$$1.2 : r = 0.6 : 2$$
$$r = \frac{1.2 \times 2}{0.6} = 4 \text{ Å}$$
$$\therefore \quad \frac{q}{r} = \frac{1.2}{4} = 0.3$$

30. (a)

$$\sigma_T = \sigma_o + K\varepsilon_T^n \quad \text{...(i)}$$
$$\Rightarrow \quad \frac{d\sigma_T}{d\varepsilon_T} = 0 + K \cdot n \cdot \varepsilon_T^{n-1}$$
$$= Kn\varepsilon_T^{n-1} \quad \text{...(ii)}$$

From equation (i)

$$K = \frac{\sigma_T - \sigma_O}{(\varepsilon_T)^n}$$

Substituting the above value in equation (ii)

$$\frac{d\sigma_T}{d\varepsilon_T} = \left(\frac{\sigma_T - \sigma_O}{\varepsilon_T^n}\right)\left(n\,\varepsilon_T^{(n-1)}\right) = \frac{(\sigma_T - \sigma_O)n}{\varepsilon_T}$$
$$= \frac{(300 - 200) \times 0.3}{0.05} = 600 \text{ MPa}$$

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