CLASS TEST

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MATERIAL SCIENCE

MECHANICAL ENGINEERING

Date of Test : 26/06/2022

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (d)

The properties of ceramics are:

1. Extremely brittle 2. High thermal stability
3. High chemical stability 4. High hardness

3. (c)

There is a invariant reaction, which does not appear on Fe-C diagram is called peritectoid reaction. When two solid phases combine together produces third solid phase upon cooling.

$$S_1 + S_2 \underset{\text{Heating}}{\overset{\text{Cooling}}{\rightleftarrows}} S_3$$

4. (c)

Fluidity is maximum for pure materials and eutectics. It is directly affected by the extent of mushy zone. Larger is the mushy zone lower will be the fluidity. Eutectic composition has higher fluidity. In any alloy system there will be at a particular composition there will be eutectic composition where there is no mushy zone. So, that particular composition has the highest/higher fluidity.

Fluidity has no relation with eutectoids.

5. (c)

Generally density is lower for low melting point material.

6. (b)

A quantum dot is a zero dimensional nanoparticle with electrons confined in all the directions.

7. (c)

Martensite is the hardest phase of iron which can be obtained after quenching of Austenitic Iron.

9. (d)

The dislocations have inherent tendency to keep smallest possible burger's vector, which enhances the stability of crystal.

10. (d)

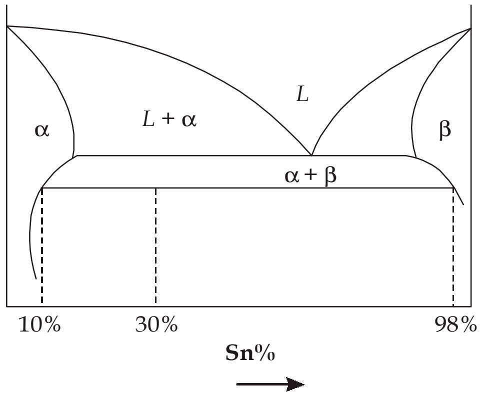
Galvanic seres order of given materials:

$$\xleftarrow{\text{Cathode}}$$

$$\text{Ni} \rightarrow \text{Bronze} \rightarrow \text{Cu} \rightarrow \text{Brass} \rightarrow \text{Pb}$$

$$\xrightarrow[\text{Anode}]{}$$

11. (c)



$$m_\alpha = \frac{(98-30)}{(98-10)} = \frac{68}{88}$$

$$m_\beta = 1 - \frac{68}{88} = \frac{20}{88}$$

Now, density of α and β,

$$\frac{100}{\rho_\alpha} = \frac{10}{\rho_{Sn}} + \frac{90}{\rho_{Pb}} = \frac{10}{10} + \frac{90}{17} = \frac{107}{17}$$

$$\rho_\alpha = \frac{17 \times 100}{107}$$

Now, for ρ_β,

$$\frac{100}{\rho_\beta} = \frac{98}{\rho_{Sn}} + \frac{2}{\rho_{Pb}} = \frac{98}{10} + \frac{2}{17} = \frac{1686}{170}$$

$$\rho_\beta = \frac{17000}{1686}$$

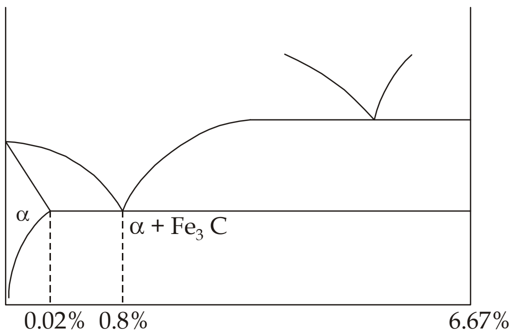
$$V_\alpha = \frac{\frac{m_\alpha}{\rho_\alpha}}{\frac{m_\alpha}{\rho_\alpha} + \frac{m_\beta}{\rho_\beta}} = \frac{\frac{68}{88} \times \frac{107}{17 \times 100}}{\frac{68 \times 107}{88 \times 17 \times 100} + \frac{20 \times 1686}{88 \times 17000}} = \frac{1}{1 + \frac{20 \times 1686}{68 \times 1070}}$$

$$= 0.6833 = 68.33\,\%$$

And, $V_\beta = 1 - 0.6833 = 0.3167 = 31.67\%$

12. (b)

$$m_\alpha = \frac{6.67 - 0.8}{6.67 - 0.02} = 88.3\%$$



13. (c)

Annealing is the heating of steel to austenite temperature and then cooling slowly in the furnace.

1. To reduce hardness
2. To improve machinability
3. To increase ductility
4. To relieve internal stresses
5. To reduce or eliminate structural inhomogeneity
6. To prepare steel for subsequent heat treatment

15. (d)

High temperature tempering: Martensite is heated to approximately 500 to 650°C and then cooled slowly in the furnace. Submicroscopic cementite will combine together and produces a coarse structure this microstructure is called sorbite.

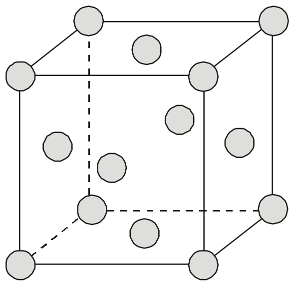
Medium temperature tempering: In this tempering process since the temperature is low so diffusion will also be low. So the cementite will appear at a finer level as compared to sorbite. This microstructure is called troosite. It is used for manufacturing of spring.

Sorbite structure is coarse as compared to troostie and troosite structure is finer structure.

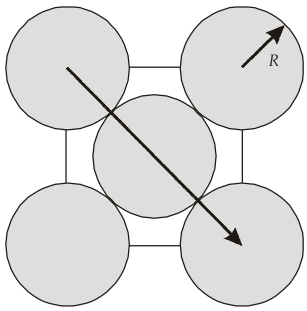
16. (b)

Crystal system	Axial relationship	Interaxial anagles
Hexagonal	$a = b \neq c$	$\alpha = \beta = 90°, \gamma = 120°$
Rhombohedral	$a = b = c$	$\alpha = \beta = \gamma \neq 90°$
Monoclinic	$a \neq b \neq c$	$\alpha = \gamma = 90° \neq \beta$
Triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90°$

17. (c)



(a)



(b)

(i) Linear density along X-Z $= \dfrac{\text{No. of atoms centered on direction vector}}{\text{Length of direction vector}}$

$$= \frac{2\text{ atoms}}{4R} = \frac{1}{2R}$$

(ii) Planer density $= \dfrac{\text{No. of atoms centered a plane}}{\text{Area of plane}}$

$$= \frac{2\text{ atoms}}{8R^2} = \frac{1}{4R^2}$$

18. (c)

Effective number of atoms in a diamond cubic unit cell $= \frac{1}{8} \times 8 + \frac{1}{2} \times 6 + 4 = 8$

Volume of each spherical atom $= \frac{4}{3}\pi r^3$

Where r is the atomic radius of carbon atom.

Radius of atom, $r = \frac{a\sqrt{3}}{8}$, where a is the lattice parameter.

Volume of atoms in unit cell= $8 \times \frac{4}{3}\pi r^3 = \frac{32}{3}\pi r^3 = \frac{32}{3} \times \pi\left(\frac{a\sqrt{3}}{8}\right)^3$

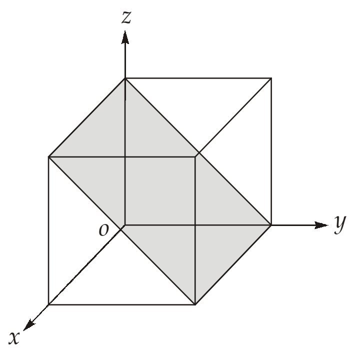
$$= \frac{32}{3} \times \frac{\pi 3\sqrt{3}}{512} \times a^3 = \frac{\pi\sqrt{3}}{16} a^3 = 0.34a^3$$

Now,Atomic packing factor= $\frac{\text{Volume of atoms in unit cell}}{\text{Volume of cubic in unit cell}} = \frac{0.34a^3}{a^3}$

APF = 0.34

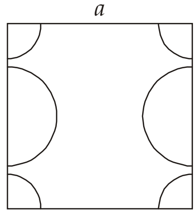
19. (d)

$$\text{Planer density} = \frac{\text{No. of atoms centered a plane}}{\text{Area a plane}}$$



Number of atoms = 2

Now, Area of plane = $\sqrt{2}a \times a = \sqrt{2}a^2$



$$\text{Planer density} = \frac{2}{\sqrt{2}a^2} = \frac{2}{\sqrt{2}a^2}\,\text{m}^{-2} = \frac{2}{\sqrt{2} \times 0.5^2 \times 10^{-9\times 2}}$$

$$= 4\sqrt{2}\ \text{nm}^{-2}$$

20. (a)

λ = 0.58Å

θ = 9.5° for n = 1, first order

a = Lattice parameter of unit cell

Inter planer distance, $d = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$

d_{200} = Mean distance for (200 plane),

where, $h = 2$, $k = 0$, $l = 0$,

$$d_{200} = \frac{a}{\sqrt{2^2 + 0^2 + 0^2}} = \frac{a}{2} = 0.5a$$

As per Bragg's law, $2d\sin\theta = n\lambda$

$2 \times d \times \sin 9.5 = 1 \times \lambda$

$2 \times \frac{a}{2} \times 0.165 = 0.58$

a = 3.515Å

21. (b)

There is no extra half plane of atoms (as in the case of edge dislocation), but a screw dislocation (atoms distorted along an helix of a screw) is formed when a part of the crystal displaces angularly over the remaining part, as if a shear stress has produced this dislocation.

22. (a)

$$\text{Yield strength} = \frac{(P)_{YP}}{A} = \frac{(P)_{YP}}{\frac{\pi}{4}d^2}$$

$$210 = \frac{4\times(P)_{YP}}{\pi\times 10^2}$$

$$(P)_{YP} = 210\times\frac{22}{7}\times\frac{10^2}{4} = 16500$$

$$(P)_{YP} = 16.5 \text{ kN}$$

$$\text{Now,Actual breaking stress, } \sigma_f = \frac{(P)_{\text{Fracture}}}{(A)_{\text{neck}}} = \frac{(P)_{\text{Fracture}}}{\frac{\pi}{4}\times d^2{}_{\text{neck}}}$$

$$\sigma_f = \frac{4\times 1.1\times 16.5\times 10^3}{\frac{22}{7}\times 7^2} = 471.43 \text{ MPa}$$

23. (d)

$$\text{BHN} = \frac{P\text{ (in kg)}}{\frac{\pi D}{2}\left[D-\sqrt{D^2-d^2}\right]} = \frac{\left(\frac{4900}{9.8}\right)}{\frac{\pi\times 10}{2}\left[10-\sqrt{10^2-\left(\sqrt{1.99}\right)^2}\right]}$$

$$= \frac{7\times 50\times 2}{22\times 10\left[10-\sqrt{100-1.99}\right]} = \frac{700}{22\left[10-\sqrt{98.01}\right]}$$

$$= \frac{700}{22[10-9.9]} = \frac{700}{22\times 0.1} = 318.182$$

24. (b)

BCC and HCP crystals are most susceptible to hydrogen embrittlement but FCC metals are generally not susceptible.

25. (d)

Every solid and liquid mater in the nature will have some impurity of sulphur. Sulphur after reacting with iron produces iron sulphite (FeS). FeS gets accumulated on the grain boundaries and is having lower melting point. Upon hot working the material FeS melts out producing number of cracks on the grain boundaries. As a result of that material will fail as brittle fracture. This phenomenon is called 'Hot shortness'. To avoid this phenomenon Mn is added into the material. 'Mn' captures sulphur before it can react with iron. Also a larger number of 'MnS' pockets will be present in the materials. Which improves the machinability because MnS is having low shear strength. If 'Mn' is around 12% the strength of material appears to be very high called 'Hadfield steel', which is used to make bull-dozer rolls.

26. (c)

$$(m)_{\text{polymer sample}} = m_a + m_c$$
$$\rho V = \rho_a V_a + \rho_c V_c$$
$$\rho\left(\frac{V_c}{V_a}+1\right) = \rho_a + \rho_c \frac{V_c}{V_a}$$
$$\rho = \frac{\rho_a + \rho_c f_c}{1+f_c}$$

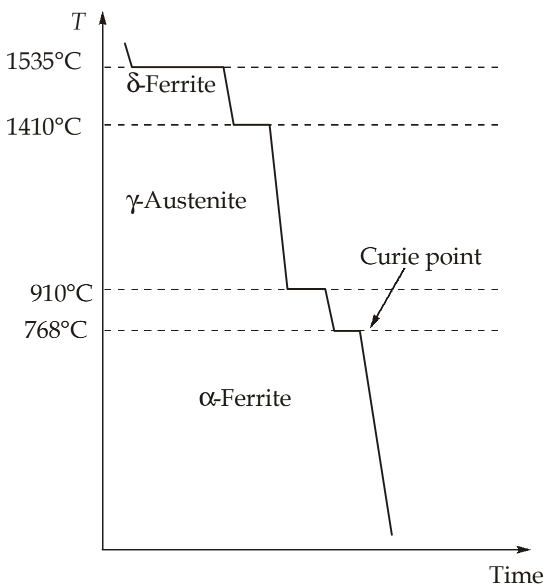
27. (d)

Upon quenching liquid metals at a very fast rate (10^6 °C/sec) the metal will also convert into glass called metallic glass and is used in transformer cores to minimize the eddy current losses.

28. (c)

Polyvinyl chloride (PVC), polypropylene (PP), polyethylene (PE) and polystyrene (PS) are thermoplastics, known as B1G-4. Other well known thermoplastics are poly tetra fluoro ethylene, acrylic etc. The commonly used thermosetting plastics are epoxy, polyster and phenol formaldehyde (Bakelite) etc. Most of these thermosetting plastics are used as matrix in composite materials.

29. (d)



30. (d)

Jominy distance in Jominy end quench test indicates the hardenability of the material and it will be maximum for eutectoid composition. If we deviate from 0.8% carbon composition i.e. eutectoid point we do not get martensite structure which is harder.

■■■■