POSTAL Book Package 2023

Mechanical Engineering

Objective Practice Sets

Material Science

Contents

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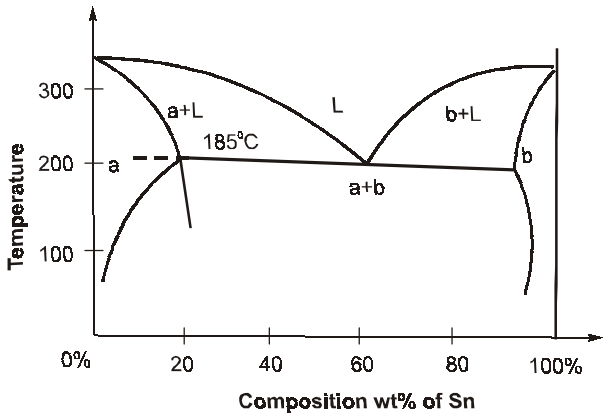
2 CHAPTER
Equilibrium Diagram and Phase Changes

MCQ and NAT Questions

Q.1 Ferrites are
(a) Ferro-magnetic (b) Ferrimagnetic
(c) Para-magnetic (d) anti-magnetic

Q.2 Consider the following lead-tin phase diagram given below :



For which one of the following alloy compositions, the alloy will have the lowest melting point at 185°C?
(a) 20% Sn and 80% Pb by weight
(b) 60% Sn and 40% Pb by weight
(c) 97% Sn and 3% Pb by weight
(d) 40% Sn and 60% Pb by weight

Q.3 In peritectoid reaction on cooling, we get one solid phase from
(a) two liquid phases
(b) two solid phases
(c) one solid & one liquid phase
(d) none of these

Q.4 Match **List-I** (Phase diagram) with **List-II** (Characteristic) and select the correct answer using the codes given below the lists:

List-I
A. Isomorphous system
B. Eutectic system
C. Peritectic system
D. Monotectic system

List-II
1. One liquid decomposes into another liquid and solid
2. One liquid and another solid combine to form a new solid
3. Two metals are completely soluble in liquid state and completely insoluble in solid state
4. Two metals, soluble in solid and liquid state

Codes:

	A	B	C	D
(a)	2	3	4	1
(b)	4	1	2	3
(c)	2	1	4	3
(d)	4	3	2	1

Q.5 Which one of the following reaction is eutectic reaction in Iron-carbon equilibrium diagram.

(a) $\text{Austenite}(\gamma) \underset{\text{heating}}{\overset{\text{cooling}}{\rightleftharpoons}} \text{ferrite}(\alpha)$ + cementite (Fe_3C)

(b) $\alpha + \gamma \underset{\text{heating}}{\overset{\text{cooling}}{\rightleftharpoons}} Fe_3C$ (cementite)

(c) $Fe_3C + \gamma \underset{\text{heating}}{\overset{\text{cooling}}{\rightleftharpoons}} \alpha$

(d) $L \underset{\text{heating}}{\overset{\text{cooling}}{\rightleftharpoons}} \gamma + Fe_3C$

Q.6 Match **List-I** (Fe-Fe_3C Phase Diagram Characteristic) with **List-II** (Phase) and select the correct answer using the codes given below the lists:

List-I
A. Alpha (α) iron
B. Iron carbide having crystal lattice
C. BCC pure allotrope of iron is stable between 1388°C & its melting point at 1535°C

(a) Fraction of total ferrite is 0.95.
(b) Fraction of cementite is 0.05.
(c) Fraction of proeutectoid ferrite is 0.373.
(d) Fraction of pearlite is 0.577.

Q.34 A Cu-Ni alloy having 53% Ni is cooled from liquid state to 1300°C temperature. The tie-line intersects solidus and liquidus line at 42% Cu and 55% Cu at 1300°C respectively. Which of the following statements is(are) true about Cu-Ni phase diagram?

(a) Cu-Ni phase diagram is an example of binary isomorphous phase diagram.
(b) When there is a total solubility both in solid as well as in liquid state then for such an alloy melting point is not fixed such as for Cu-Ni alloys.
(c) % of liquid at 1300°C in alloy is 61.54%.
(d) % of solid at 1300°C in alloy is 38.46%.

■■■■

Answers Equilibrium Diagram and Phase Changes

1. (a)	**2.** (b)	**3.** (b)	**4.** (d)	**5.** (d)	**6.** (b)	**7.** (a)	**8.** (c)	**9.** (a)
10. (a)	**11.** (c)	**12.** (d)	**13.** (d)	**14.** (b)	**15.** (a)	**16.** (c)	**17.** (b)	**18.** (c)
19. (b)	**20.** (b)	**21.** (c)	**22.** (d)	**23.** (a)	**24.** (c)	**25.** (c)	**26.** (a)	**27.** (c)
28. (c)	**29.** (c)	**30.** (a, b)	**31.** (c, d)	**32.** (a, b)	**33.** (a, b)	**34.** (a, b)		

Explanations Equilibrium Diagram and Phase Changes

1. (a)

Ferrites are solid solution of carbon in α-iron which is of bcc structure, has ferro-magnetic character.

2. (b)

At eutectic point, alloy will have lowest melting point, which occurs at 60% Sn and 40% Pb alloy composition.

3. (b)

When two solids combine together to form a single solid, it is peritectoid reaction.

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

4. (d)

Isomorphous system refers complete solubility in liquid as well as solid state.

Peritectic : liq + solid $A \longrightarrow$ Solid B
Peritectoid : Solid A + solid $B \longrightarrow$ Solid C
Eutectoid : Solid $A \longrightarrow$ Solid B + Solid C
Eutectic : Liquid $\longrightarrow$ Solid A + Solid B
Monotectic : Liquid $A \longrightarrow$ Liquid B + Solid C

5. (d)

In iron-carbon equilibrium diagram, eutectic reaction results in liquid converting into two different solids.

$$L \underset{\text{Heating}}{\overset{\text{Cooling}}{\rightleftharpoons}} \gamma + Fe_3C$$

6. (b)

Alpha (α) iron:

- Stable upto 910°C
- Maximum solubility of carbon is 0.025%@723°C
- Minimum solubility of carbon is 0.0025%@room temperature.
- Structure-BCC and magnetic in nature.

δ-iron:

- It contains very small carbon, maximum solubility of carbon is ≈ 0.10% at 1495°C.

7. (a)

Malleable CI	:	120
Grey CI	:	130
Nodular CI	:	180
White CI	:	400

8. (c)

- Black iron has carbon % from 2.2 to 2.8%. Black iron is given by Fe_3O_4.
- White iron has 3.2 to 3.6% of carbon.

9. (a)

It represents the shortest time required for specified fraction of transformation.

10. (a)

Increasing phosphorous from 0.45 to 2.85% in gray cast iron increases the amount of eutectic phosphide which results in weakening the mechanical properties like tensile strength reduces, impact strength decreases, hardness increases. It increases the porosity which is not good for mechanical applications.

It increases fusibility, fluidity but reduces brittleness.

11. (c)

According to Gibb's phase rule,

Number of degree of freedom,

$F = C - P + 1$

where, C = number of components; P = number of phases

For binary system, C = 2

and for eutectic point, $P = 3$

$\therefore \quad F = 2 - 3 + 1 = 0$

12. (d)

The analysis of problems involving the casting of alloys requires a complex blend of fluid mechanics, heat flow, chemical diffusion and solid mechanics. Phase diagrams, especially when applied to the character of a material at a given position and time (local equilibrium), provides the basic constitutive relation regarding the physical state of the alloy. A major use of phase diagrams comes about in the prediction of the degree of micro-segregation and inclusion.

A modern approach to study phase diagrams lies in the various applications like alloy making, soldering, semi-conductor devices, zone refining etc.

13. (d)

The correct option is (d) i.e., all of the above.

Iron carbon equilibrium diagram indicates the phase changes, that occur during heating and cooling and the nature and amount of the structural component that exist at any temperature. Besides it establishes a correlation between the microstructure and properties of steel and cast irons and provides a basis for the principles of heat treatment.

14. (b)

- Phase is physically and chemically homogeneous composition of a substance.
- Degree of freedom is the number of independent variables required to describe the state of system.
- Equilibrium is state of a system at any specified condition when the system possesses minimum free energy.
- Components are elements that constitute a system.

15. (a)

Iron-carbon equilibrium diagram terminates at 6.67% carbon, we do not study ahead of 6.67%, because all commercial alloys are made by carbon composition well below 6.67%.

16. (c)

Molybdenum adds corrosion resistance and high temperature strength. Therefore, it shifts the lower critical temperature line in iron-iron carbon equilibrium diagram towards the higher side.

17. (b)

Austenite has face centered cubic structure other materials like Copper, Aluminium, Nickel has also FCC structure.

18. (c)

According to lever rule:

Amount of solid phase

$$= \frac{(40-32)}{(68-32)} \times 100 = 22.2\%$$

Amount of liquid phase

$$= \frac{(68-40)}{(68-32)} \times 100 = 77.8\%$$

19. (b)

In peritectoid reaction on cooling, we get one solid phase from two solid phases.