Material Science

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Chapter 6. Phase Diagrams

Highlights, Motivation and Critical Concepts:

Materials can exist in different or phases. During processing, material can change its microstructure, compositions and might be able to co-exist with different phases. The equilibrium conditions can be tailored according to the need of the hour. Co-existence of different phases under equilibrium conditions can be depicted using phase diagrams. This gives an understanding of microstructures obtainable, and thus the mechanical properties of product phases. Hence, it is necessary to be able to construct, interpret and use phase diagrams in processing of materials. Interpretation of phase diagrams involves identifying phases present, their composition and their relative amount under given conditions. An interesting part of phase diagrams is location of different invariant reactions, and their influence on cooling curve passing through the region of it. This can be done using phase rule, lever rule along with a tie-line constructed. This chapter is devoted to the above said task. Classification of different systems according to number of component present is explained. It is followed by detailed study of various binary systems. Along with general systems, an important binary system of Fe and C is dealt in details. This is because steels constitute greatest amount of metallic materials used by man, and solid state transformations that occur in steels are varied and interesting.

Multiple Choice Questions' Bank:

1. Gibbs phase rule for general system:

(a) P+F=C-1 (b) P+F=C+1 (c) P+F=C-2 (d) P+F=C+2

2. In a single-component condensed system, if degree of freedom is zero, maximum number of phases that can co-exist _____.

(a) 0 (b) 1 (c) 2 (d) 3

3. The degree of freedom at triple point in unary diagram for water _____.

(a) 0 (b) 1 (c) 2 (d) 3

4. Above the following line, liquid phase exist for all compositions in a phase diagram.

(a) Tie-line (b) Solvus (c) Solidus (d) Liquidus

5. Following is wrong about a phase diagram.

(a) It gives information on transformation rates.
(b) Relative amount of different phases can be found under given equilibrium conditions.
(c) It indicates the temperature at which different phases start to melt.
(d) Solid solubility limits are depicted by it.

6. Not a Hume-Ruthery condition:

(a) Crystal structure of each element of solid solution must be the same.
(b) Size of atoms of each two elements must not differ by more than 15%.
(c) Elements should form compounds with each other.
(d) Elements should have the same valence.

7. Pick the odd one in the following:

(a) Isomorphous alloy (b) Terminal solid solution
(c) Intermediate solid solution (d) Compound

8. The boundary line between (liquid) and (liquid+solid) regions must be part of _____.

(a) Solvus (b) Solidus (c) Liquidus (d) Tie-line

9. The boundary line between (liquid+solid) and (solid) regions must be part of _____.

(a) Solvus (b) Solidus (c) Liquidus (d) Tie-line

10. The boundary line between (alpha) and (alpha+beta) regions must be part of _____.

(a) Solvus (b) Solidus (c) Liquidus (d) Tie-line

11. Horizontal arrest in a cooling curve represents:

(a) Continuous cooling (b) Invariant reaction (c) Both (d) None

12. Relative amounts of phases in a region can be deduced using

(a) Phase rule (b) Lever rule (c) Either (d) None

13. An invariant reaction that produces a solid up on cooling two liquids:

(a) Eutectic (b) Peritectic (c) Monotectic (d) Syntectic

14. A solid + a liquid result in a liquid up on heating during _____ reaction.

(a) Eutectic (b) Peritectic (c) Monotectic (d) Syntectic

15. A solid + a liquid result in a solid up on cooling during _____ reaction.

(a) Eutectic (b) Peritectic (c) Monotectic (d) Syntectic

16. On heating, one solid phase results in another solid phase plus on liquid phase during ___ reaction.

(a) Eutectic (b) Peritectic (c) Monotectic (d) Syntectic

17. A solid phase results in a solid plus another solid phase up on cooling during _____ reaction.

(a) Eutectoid (b) Peritectoid (c) Eutectic (d) Peritectic

18. A solid phase results in a solid plus another solid phase up on heating during _____ reaction.

(a) Eutectoid (b) Peritectoid (c) Monotectoid (d) None

19. A liquid phase produces two solid phases during _____ reaction up on cooling.

(a) Eutectic (b) Eutectoid (c) Peritectic (d) Peritectoid

20. Liquid phase is involved in the following reaction:

(a) Eutectoid (b) Peritectoid (c) Monotectoid (d) None

21. Not a basic step of precipitation strengthening

(a) Solutionizing (b) Mixing and compacting (c) Quenching (d) Aging

22. Both nucleation and growth require change in free energy to be _____.

(a) –ve (b) zero (c) +ve (d) Any

23. During homogeneous nucleation, critical size of a particle _____ with increase in under-cooling.

(a) Increases (b) Decreases (c) Won’t change (d) Not related

24. Not a typical site for nucleation during solid state transformation

(a) Container wall (b) Grain boundaries (c) Stacking faults (d) Dislocations

25. Growth occurs by

(a) Diffusion controlled individual movement of atoms
(b) Diffusion-less collective movement of atoms
(c) Both (d) None

26. Overall transformation rate changes with temperature as follows:

(a) Monotonically decreases with temperature (b) First increases, then decreases
(c) Initially it is slow, and then picks-up (d) Monotonically increases with temperature

27. wt.% of carbon in mild steels

(a) <0.008 (b) 0.008-0.3 (c) 03-0.8 (d) 0.8-2.11

28. Eutectic product in Fe-C system is called

(a) Pearlite (b) Bainite (c) Ledeburite (d) Spheroidite

29. Eutectoid product in Fe-C system is called

(a) Pearlite (b) Bainite (c) Ledeburite (d) Spheroidite

30. Phases that exist on left side of an invariant reaction line are called

(a) Pro-phase (b) Hypo-phase (c) Hyper-phase (d) None

31. Alloying element that decreases eutectoid temperature in Fe-C system

(a) Mo (b) Si (c) Ti (d) Ni

32. Nose of a C-curve represents

(a) Shortest time required for specified fraction of transformation
(b) Longest time required for specified fraction of transformation
(c) Average time required for specified fraction of transformation
(d) No information regarding time required for specified fraction of transformation

33. Phase formed of diffusion-less reaction:

(a) Pearlite (b) Lower Bainite (c) Upper bainite (d) Martensite

34. Ms for Fe-C system is round _____ ℃.

(a) 725 (b) 550 (c) 450 (d) 210

35. Impurity not responsible for temper embrittlement

(a) Sn (b) Sb (c) Si (d) As

Answers:

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