

# MARIA COLLEGE OF ENGINEERING AND TECHNOLOGY, MARTHANDAM

DEPARTMENT OF MECHANICAL ENGG. | ME 2253 - ENGINEERING MATERIALS AND METALLURGY  
IIYEAR (4<sup>th</sup> SEMESTER)

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1. Define Solid solution.

Two metals combined together to form a single structure

2. Name the two kinds of Solid Solutions

Substitutional

Interstitial

3. How the substitutional Solutions are formed.

When the Solute atoms replace Solvent atoms

4. How the Interstitial Solutions are formed.

When the Solute atoms are small enough to occupy the holes between the Solvent atoms

5. What are the factors governing Solid solubility?

Crystal structure

Relative atomic

size Chemical

affinity Valency

6. What is Phase diagram?

The phase diagram indicates the temperature at which the solid alloy will start melting and finish melting.

7. What are the types of phase diagrams?

Unary

Binary

Ternary

8. What are the Coordinates of phase diagram?

Temperature and Time

9. What is Isomorphous Reactions?

Two metals that is completely soluble in Liquid state and solid state.

10. Give some examples of Isomorphous alloy systems.

Copper and

nickel Gold

and silver Iron

and vanadium

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11. What is Eutectic Reactions?

Two metals that are completely soluble in Liquid state and partly or insoluble in the solid state

12. Give the Reaction happening in Eutectic?



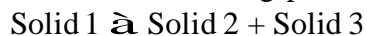
13. What is Peritectic Reactions?



14. What is Eutectoid Reactions?

This reaction is due to the transformation in solid state

15. Give the Reaction taking place in Eutectoid?



16. Write an example of the eutectoid reaction occurs in the Iron Carbon System



17. What is Peritectoid Reactions?

This reactions is due to the transformation of two Solids in to third solid state

18. Give the Reaction taking place in Peritectoid ?



19. Why Iron-Iron Carbide diagram is important/

It is the most important binary alloy system in engineering alloys because we get important alloys Cast Iron and steel.

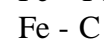
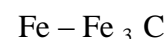
20. What is the content of steel?

It contains 0.008% to 2.14 wt% C in Fe.

21. What is the content of Cast Iron?

It contains 2.14% to 6.7 wt% C in Fe.

22. What are the two-phase diagrams of Iron-carbon system?



Here Fe – Fe<sub>3</sub> C is the portion of Fe – C phase diagram.

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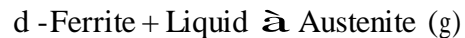
23. What are the four solid phases in the iron-iron carbide diagram?

1.  $\delta$ -Ferrite
2. Austenite (g)
3. Cementite
4.  $\alpha$ -Ferrite

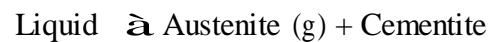
24. What are the reactions taking place in the Iron-Carbide diagram?

Peritectic  
Eutectic  
Eutectoid

25. What is the Peritectic reaction in Iron-Carbide diagram?



26. What is the Eutectic reaction in Iron-Carbide diagram?



27. What is the name of this combination Austenite (g) + Cementite?

Ledubrite

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28. What is the Eutectoid reaction in Iron-Carbide diagram?

Austenite (g)  $\rightarrow$   $\alpha$  - Ferrite + Cementite

29. What is the name of this combination  $\alpha$  - Ferrite + Cementite?

Pearlite

30. What is Hypoeutectoid and Hypereutectoid steel?

A composition Left to the Eutectoid Composition is Hypoeutectoid

A composition Right to the Eutectoid Composition is Hypereutectoid

31. Write the classification of steel ?

Low carbon

Medium carbon

High Carbon

Tool steel

31. How the steel classified?

According to the carbon content in Fe.

32. What are the types of Cast iron?

Gray

Nodular

White

Malleable

33. What is Heat treatment of metal?

Combination of heating, holding and cooling

34. Write some objectives of Heat treatment?

1. To Relieve internal stresses

2. To improve Machinability

3. To improve the properties

35. What are the types of heat Treatment?

Annealing

Normalising

Hardening

Tempering

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36. What are the types of Annealing?

- Full
- Stress-relief
- Recrystallization
- Spheroidizing
- Process

37. What is the process in Full Annealing?

- Heating the steel 15<sup>0</sup> to 40<sup>0</sup> C above A<sub>3</sub> temperature
- Now the steel is Austenized
- Cooling very slowly in the furnace itself

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38. What is the process in Stress relief annealing?

Heating the steel up to 600 degree C Now the steel is Austenized  
Cooling very slowly in the room temp in air

39. What is the process in Recrystallization or process annealing?

Heating the steel 600 to 650 degree C Now the steel is Austenized  
Cooling very slowly in the room temp in air

40. What is the Spheroidizing?

The cementite is hard to machine because of its needle like structure So heated to about 700 degree C. Now the Cementite becomes globular structure Called Spheroids which will be easy to machine.

41. What is Normalising?

Annealing Heat treatment process called normalizing.  
Heating the steel 55<sup>0</sup> to 85<sup>0</sup> C above A3 temperature  
Hold for 15 minutes. Now the steel is Austenized  
Cool down in still air

42. What is the purpose of normalizing?

To refine the grain size  
To produce more uniform and desirable size distribution.

43. what is the abbreviation of TTT-diagram?

Time, Temperature and Transformation of Austenite.

44. what are the other names of TTT diagram?

Isothermal Transformation(IT-diagram) curves and S-curve,C-curve due to their shapes

45. How to obtain IT – diagram?

Normally upon cooling austenite transforms to Pearlite(ferrite + cementite)

46. what are the co-ordinates of IT-diagram?

Amount of Austenite transformed in vertical axis(Y-axis)

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Time (Logarithmic scale, so we can use for days, weeks, months) in X-axis

47. What are the products you came to know from IT-diagram?

- AT 700<sup>o</sup> C Coarse Pearlite
- AT 600<sup>o</sup> C upper Bainite ( Sorbite )
- AT 500 to 550<sup>o</sup> C Fine Pearlite (Troosite)
- AT 550 to 300<sup>o</sup> C Lower Bainite (acicular troosite)

48. What is Hardness?

Resistance to plastic deformation

49. What is Hardening?

Hardening is process in which the metal is heated to the austenizing temp and suddenly cooled in cold water.

50. What is the reason for Hardening?

Martensite is formed from Austenite directly. This is a complex structure formed due to sudden cooling.

51. What is Tempering?

In Hardening the metal becomes too brittle and with lot of internal stresses which would affect the property of metal. To remove this and to get desired property we reheat the hardened metal. This process is called Tempering.

52. What is Martempering?

If we reheat the after Martensite formation

53. What is Austempering?

Transformation directly to Bainite formation

54. What are the three types of Tempering?

- Low temperature
- High temperature
- Medium Temperature

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55. What are the types of hardening process?

Work  
Hardening Age  
Hardening Air  
Hardening  
Hardening by heating and quenching

56. What is Hardenability?

Penetration of Hardness in the metal

57. What is the test to find Hardenability?

Jominy Quench Test

58. What is case hardening?

The surface of the steel is more hard and wear resistant whereas the core remains soft and tough.

Example: in gears, ball bearings

59. What are the various types of case Hardening?

Carburizing, Cyaniding, Nitriding, Flame and Induction Hardening

60. What is alloy steel?

Steel in which other elements are added other than carbon.

61. What are the effects of alloying additions on steel?

To increase Strength, Hardness, Toughness, Properties

62. How stainless steel divided?

Martensitic, Ferritic, Austenitic

Plain carbon

Low alloy

High speed

High Chromium High Carbon steels

64. What is HSLA steels?

High Strength low alloy steels, which have, better mechanical properties.

65. What are Maraging steels?

Martensite aging. Steels with greater Tensile strength (ultra high strength steels)



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66. How copper alloys classified?

Copper-Zinc  
Copper-Tin

67. what are the types of bronze?

Phosphorous  
Silicon  
Beryllium  
Manganese  
Aluminium

68. What are the three main steps in precipitation Strengthening treatment?

Solution Treatment  
Quenching  
Aging

69. Define the term polymer.

Poly- many  
Mer-single unit  
Polymer – many units joined together

70. What are the naturally occurring polymers?

Wood, rubber, leather etc.

71. What are the synthetic polymers?

Nylon, Terlyene, Poly ethylene ....

72. What is polymerization?

Small molecules combine to form large molecule.

73. What are the types of polymerization?

1. Addition
2. Condensation

74. What is the difference between Addition and condensation polymerization?

Addition – no by product formed  
Condensation – by product formed

75. How are polymers classified?

Thermoplasts, Thermosets

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76. What is the difference between Thermoplasts and Thermosets?

Thermosets cannot be remoulded

Thermoplasts can be remoulded

77. Define ceramics?

Ceramics are compounds of metallic and non-metallic elements. Ex:  
stone, brick, clay, glass

78. What does new ceramic material include?

Oxides, carbides, borides and other similar compounds

79. Name two refractory materials.

Magnesia

Alumina

80. What is composite material?

Two or more materials with superior properties combined together to form new product.

81. Write an example for composite material?

Cement concrete, glass reinforced plastic, plywood

82. What are the different types of composites?

Particle

reinforced Fibre

reinforced

Structural

83. What is matrix and reinforcement?

The major element molten metal is matrix. The material which is added to improve the properties is reinforcement.

84. How are the metals classified?

Ferrous (Iron-based)

Non-Ferrous (non Iron-based)

85. What are the two types of Deformation in metals?

Plastic Deformation

Elastic Deformation

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86. What is plastic deformation?

When a body is subjected to a force, it will tend to deform. When the deformation exceeds the elastic limit it will not regain to its original form

87. What is Elastic deformation?

When a body is subjected to a force, it will tend to deform. When the deformation within the elastic limit it will regain to its original form

88. In what ways plastic deformation takes place?

Two methods

1. Slipping

2. Twinning

89. Define slipping.

It is defined as the shear transformation, which moves the atoms over a number of interatomic distances relative to their initial position.

90. Define Twinning.

It is the two plastic deformations which takes place along two planes due to set of forces acting on a given metal.

91. Define fracture.

Separation of Solids into two Parts.

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92. What are the two components of the process of fracture?  
Crack initiation  
Crack propagation
93. What are the different types of fracture/  
Brittle  
Ductile  
Fatigue  
Creep
94. What is the use of izod test?  
To determine the impact strength of the material
95. What is the yield strength?  
The material yield without a change in the load
96. What are the tests conducted in the material?  
Impact test, hardness test, shear test, tensile test, fatigue test, creep test
97. What is fatigue fracture?  
It is the fracture that occurs under repeatedly applied fatigue stresses
98. What is Brittle fracture?  
It takes place with minimum of plastic deformation and very rapid crack propagation.
99. What is creep fracture?  
It is the fracture that takes place due to excessive creeping of metals under steady loading and high temperature.
100. What is the need of mechanical test?  
In order to determine which material is best by knowing the properties such as hardness, ductility, Strength.
1. Discuss the similarities and differences between substitutional and interstitial solid solutions. (Refer Page No: 1.5 - 1.8 in V. Jayakumar and Intro to physical metallurgy, SYDNEY AVNER)

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2. Explain the following invariant reactions with reference to a phase diagram:

- (a) Eutectic reaction, (b) Eutectoid reaction,
- (c) Peritectic reaction, and (d) Peritectoid reaction. (Refer Page No 1.34-1.39 in V. Jayakumar and Intro to physical metallurgy, SYDNEY AVNER)

3. What are the micro-constituents of iron-carbon alloys? Explain the general characteristics of each. (Refer Page No 1.47-1.51 in V. Jayakumar and Intro to physical metallurgy, SYDNEY AVNER)

4. Draw iron-iron carbide equilibrium diagram and mark on it all salient temperatures and composition fields. (Refer Page No 1.52-1.56 in V. Jayakumar and Intro to physical metallurgy, SYDNEY AVNER)

5. Explain the primary crystallisation of eutectoid steels, hypoeutectoid steels, and hypereutectoid steels. (Refer Page No 1.57-1.62 in V. Jayakumar and Intro to physical metallurgy, SYDNEY AVNER)

6. Compare and contrast the process of full annealing, process annealing, stress relief annealing, recrystallisation annealing, and spheroidise annealing. (Refer Page No 2.4-2.11 in V. Jayakumar and Intro to physical metallurgy, SYDNEY AVNER)

7. (a) Describe the normalising process of heat treatment (Refer Page No 2.11-2.12 in V. Jayakumar and Intro to physical metallurgy, SYDNEY AVNER)

(b) Differentiate between normalising and full annealing (Refer Page No 2.12-2.13 in V. Jayakumar and Intro to physical metallurgy, SYDNEY AVNER)

8. Explain the process of martempering compare and contrast it with austempering process (Refer Page No 2.21-2.25 in V. Jayakumar and Intro to physical metallurgy, SYDNEY AVNER)

9. (a) What do you understand by isothermal transformation?

(b) What are TTT diagrams?

(c) How a TTT diagram is drawn?

(d) Draw a neat sketch of the TTT diagram for a eutectoid steel and label the regions. Mark the different products formed on this diagram. (Refer Page No 2.27-2.33 in

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V.Jayakumar) and Intro to physical metallurgy ,SYDNEY AVNER)

10. What is meant by carburising of steel? Briefly explain the various types of carburising (Refer Page No 2.50-2.56 in V.Jayakumar) and Intro to physical metallurgy ,SYDNEY AVNER)

11.(a) Give the classifications of steels. (Refer Page No 3.8 in V.Jayakumar)

(b) Describe the properties and typical applications of low medium, and high- carbon steels; (Refer Page No 3.3-3.11 in V.Jayakumar)

(c) What is an alloy steel? how are alloy steels classified? Explain them. (Refer Page No 3.13-3.15 in V.Jayakumar and Intro to physical metallurgy ,SYDNEY AVNER)

12.(a) What are the main classifications of stainless steels?

(b) Discuss the different types of stainless steel, making reference to approximate compositions, structures, heat treatments.

(c) Give typical applications for each of the main categories of stainless steel. (Refer Page No 3.22-3.28 in V.Jayakumar and Intro to physical metallurgy ,SYDNEY AVNER)

13.(a) Explain the principle characteristics of cast iron and explain the factors which affect the structure of cast iron. (Refer Page No 3.37-3.40 in V.Jayakumar)

(b) Describe the structures of the main types of cast irons and account for their continued use as engineering materials. (Refer Page No 3.41-3.48 in V.Jayakumar)

c) Compare grey and malleable cast irons with respect to

(i) composition and heat treatment, (ii) microstructure, and

(iii) mechanical characteristics. (Refer Page No 3.48-3.51 in V.Jayakumar)

(d) Compare white and nodular cast irons with respect to

(i) composition and heat treatment, (ii) microstructure, and

(iii) mechanical characteristics. (Refer Page No 3.51-3.56 in V.Jayakumar)

14. Discuss the composition, Properties, and typical applications of any four copper alloys. (Refer Page No 3.59-3.69 in V.Jayakumar)

15. Explain the composition, properties, and typical applications of some aluminium alloys. (Refer Page No 3.68-3.70 in V.Jayakumar)

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16. What do you understand by polymerisation? with the help of suitable examples, compare and contrast condensation polymerisation. (Refer Page No 4.10-4.14 in V.Jayakumar/Engineering Materials by Kenneth G. Budinski/Sydney H Avener)

17.(a) Describe the difference between thermoplastics and thermosetting plastics. (Refer Page No 4.20-4.21 in V.Jayakumar/Engineering Materials by Kenneth G. Budinski/Sydney H Avener)

(b) Explain the difference between commodity plastics and engineering plastics. (Refer Page No 4.21-4.22 in V.Jayakumar/Engineering Materials by Kenneth G. Budinski/Sydney H Avener)

18. What are Ceramics? List and briefly explain five important properties of Ceramics that make them useful engineering materials. (Refer Page No 4.52-4.55 in V.Jayakumar/Engineering Materials by Kenneth G. Budinski/Sydney H Avener)

19. Discuss the properties and typical applications of the following engineering Ceramics:

(a) Alumina (b) SiC (c) silicon nitride (d) PSZ and (e) Sialons (Refer Page No 4.56-4.65 in V.Jayakumar/Engineering Materials by Kenneth G. Budinski/Sydney H Avener)

20(a). What is the distinction between matrix and dispersed phases in a Composite material? (Refer Page No 4.66-4.68 in V.Jayakumar/Engineering Materials by Kenneth G. Budinski/Sydney H Avener)

(b) Contrast the mechanical characteristics of Matrix and dispersed phases for fibre-reinforced composites. (4.75 in V.Jayakumar/Sydney H Avener)

21. Explain the two modes of plastic deformation in metals with neat sketches. (Refer Page No 5.7-5.9 in V.Jayakumar/Sydney H Avener)

(a) Critically compare the deformation by slip and twinning (Refer Page No 5.16 in V.Jayakumar/Sydney H Avener)

(b) Derive an expression for critical resolved shear stress in material subjected to uni-axial tensile loading. Also distinguish between shear stress and critical resolved shear stress. (Refer Page No 5.12-5.14 in V.Jayakumar/Sydney H Avener)

22. What is brittle fracture? Explain the Griffith's theory on brittle fracture and deduce and expression for the critical stress required to propagate a crack simultaneously in a brittle material. (Refer Page No 5.17-5.20 in V.Jayakumar/Sydney H Avener)

23. What is meant by ductile fracture? Explain the mechanism of it. (Refer Page No

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5.21-5.23 in V.Jayakumar/Sydney H Avener)

24.(a) Explain the mechanism of fatigue fracture (Refer Page No 5.25 in

V.Jayakumar/Sydney H Avener) (b) Discuss any two mechanisms of creep fracture (Refer Page No 5.27-5.31 in V.Jayakumar)

(c) How can you prevent: (i) fatigue fracture, and (ii) creep fracture. (Refer Page No 5.27-5.31)

25.(a) Describe a tensile test to determine various tensile properties. (Refer Page No 5.33-5.38) (b) Explain the testing procedure of (i) a compression test, and (ii) a shear test. (Refer Page No

5.43 in V.Jayakumar/Sydney H Avener)